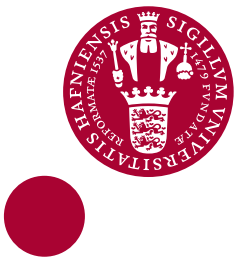

"Listen, why should I care?"

Emotion, Affect, and Expert Participation in Public Engagement about Synthetic Biology

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Abstract (English)

The role of emotion and affect in science communication is a little studied phenomenon, however emotion and affect are increasingly understood as material influences on how publics relate to science and technology. Though they are recognized as being involved in shaping public perceptions of science, it is not clear what role emotion and affect play in forming what gets communicated about science before publics even appear to engage with what has been communicated. In this PhD thesis, I study how experts who communicate publicly about the science of synthetic biology accept, resist, and transform their roles as communicating experts that are offered to them by the design of a public engagement event. I constructively analyse how they inhabit these roles using Felt and Fochler's concept of "machineries for making publics" (2010), which I interpret and operationalize as "machineries for making communicating experts." My data consists of participant interviews, process journals, and audio diaries created in this practice-based research, wherein I produced an interactive online digital audio archive about synthetic biology called Aurator (www.aurator.org). I examine the data for key patterns pertaining to ethics, performativity, authenticity and duration as they connect to the function of emotion and affect in science communication. I conclude that the science communication that gets produced in a public engagement project is directly shaped by the emotions and affects that emerge throughout the engagement event (those of communicating experts as well as those of the engagement event producer). My findings show that affect and emotion are intractable elements of how public engagement events operate, even before publics appear, and therefore are fundamental to how science communication gets made. I argue that this calls upon science engagement practitioners to apply a special ethics of care, which I call *caring for science communication*, in their work. In order to *care for science communication,* practitioners must appreciate the performative and material nature of science communication, and be able to make compromises between multiple emergent requirements for care at every step of the way as science engagement events unfold.

Resume (Dansk)

Den rolle som følelser og påvirkning (affect) spiller i videnskabskommunikation er et understuderet fænomen, men de bliver i stigende grad opfattet som værende grundlæggende for, hvordan offentligheden relaterer til videnskab og teknologi. Selvom det er anerkendt at følelser og affect er involverede i at forme offentlighedens opfattelse af videnskab, står det ikke klart, hvilken rolle de spiller i forhold til at determinere, hvad der bliver kommunikeret om videnskab, før offentligheden får mulighed for at engagere sig med det kommunikerede. I nærværende PhD afhandling om videnskabskommunikation studerer jeg, hvordan offentligt kommunikerende eksperter inden for videnskabsdisciplinen syntetisk biologi accepterer, modstår and transformerer den rolle som kommunikative eksperter der tildeles dem, når de deltager i et specifikt forsøg med *public engagement*. Jeg foretager en konstruktiv analysere af, hvordan de kommunikerende eksperter indtager deres roller som deltagere, ved at bruge Felt & Fochler's "machineries for making publics", hvilket jeg fortolker som "machineries for making communicative experts". Mine data består af deltagerinterviews, procesbeskrivelser og audiodagbøger skabt af min praksisorienterede forskning rette mod at skabe et interaktivt audioarkiv om syntesebiologi: Aurator. Jeg undersøger de indsamlede data for mønstre i, hvordan etik, autenticitet, repræsentation og tidsforløb er forbundne til følelser og affects i videnskabskommunikation. Jeg konkluderer, at den videnskabskommunikation der produceres gennem forsøget med *public engagement*, er direkte formet af de følelser og affects (fsva. både de kommunikative eksperter og producenten) der opstår gennem interaktionen. Mine analyser viser, at følelser og affect er uløseligt forbundne med, hvordan events af *public engagement* fungerer. Jeg argumenterer endvidere for, at der igennem dette arbejde tilfalder videnskabskommunikatører en særlig omsorgsetik, hvilket jeg kalder *caring for science communication*. For at kunne udøve denne omsorgsetik må videnskabskommunikatører påskønne videnskabskommunikationens performative natur og være i stand til at foretage kompromiser mellem de forskellige omsorgskrav, der opstår, når et *public engagement* event om videnskab afholdes.

Introduction

In this practice-based PhD thesis, I examine whether and how affect and emotion shape the way science communication gets produced when a communication practitioner works with expert participants to create a science engagement project. This thesis takes the form of a practice-based case study, wherein I produced an original science engagement project about synthetic biology called Aurator. In parallel, I write in this dissertation about the process of making Aurator, analyzing data that was generated throughout the production process in order to contribute to an understanding of how affects and emotions play a role in the way science communication gets made collaboratively with others. The practice-based study is generated in part by my pre-existing professional practice as a science communicator. The conceptual challenges and affordances that come from combining professional practice with scholarship is a central theme of this dissertation's discussion.

Aurator is an interactive audio diary archive that works as a web and mobile platform for listening and speaking back to the privately recorded thoughts and feelings of a select group of multidisciplinary experts who work in synthetic biology. Aurator's production process was an experiment where I solicited audio diaries over three months from several natural scientists, a social scientist, an artist, a biohacker, an entrepreneur, a watchdog, and a bioethicist after having sent them each an audio recorder by mail. I prompted these "communicating experts" with weekly recording assignments that asked them to reflect on their feelings towards various issues connected to synthetic biology. Their responses were edited, curated and entered into Aurator's online interactive platform where they can be listened to and responded to by any user who visits the site. Aurator was made in the spirit of "emergent public engagement", a model of science communication that I describe in chapter one, and its form was inspired by the growing field of i-docs (interactive documentaries), which I explain in chapter three. Aurator can be experienced by visiting www.aurator.org on a web browser (Chrome works best) or mobile. Full recording functionality

for responding to the expert diaries and creating new user diaries however only works on a web browser. The mobile version by contrast simply allows one to listen to the communicating experts' diaries that were collected during this research process.

The fact that I made Aurator (a practice-based media project) not just as a science communicator but also as a *researcher* in science communication highlights a tension that this thesis directly deals with. Namely, that this dissertation comprises both i) a practice-based study where original science communication is produced, which one can think of as "making practice" and ii) a research process that informs how my activities of "making practice" are designed as well as how I analyse their outcomes, which one can think of as "writing research." Practice-based research projects such as this raise many interesting questions about one's double-pronged position as both researcher and practitioner in one's own study, and what trade-offs that may create for a projects' success (Candy and Edmonds 2011). In my case, this became one degree even more complex, as I inhabited the triple role of researcher, practitioner and research-subject. The third role of research-subject emerged because this project is a scholarly investigation of how affect and emotion shape the way science communication gets produced. This necessitates looking at the role of the science engagement practitioner (the engagement event organizer/creator) and what influence their own emotions and affects have on how science communication is produced while designing and carrying out an engagement event. Therefore, I also became my own research subject due to my already split role as Aurator's producer. The difficulties and affordances that stemmed from my hybrid position as someone engaged in "making practice" and "writing research" are explored time and again throughout the thesis. Though they are featured most prominently in the methodology chapter where I discuss the challenges of practice-based research, and in chapter six, where I explain what I've learned from this experiment about practice-based research.

With Aurator, I was able to study how communicating experts who agreed to participate in Aurator's production accept, resist and transform the roles that are offered to them by the design of the engagement project. In particular, I analyse the way that emotions and affects shape how they inhabit their roles as participants, as well as how the affects and emotions experienced by the engagement event producer (me) during the production process impact the outcomes of Aurator. In my analysis of what happened, I use Felt and Fochler's concept of "machineries for making publics" (2010), which I transform for the needs of this research and operationalize as what I call "machineries for making communicating experts" to explain my findings.

In the first chapter I review the contemporary literature on science communication in order to isolate and describe key theories that bear relevance for the function of affect and emotion in this research, which informs my methodology. In the second chapter I discuss the field of synthetic biology and examine critical debates around its approaches to public engagement and the function of interdisciplinarity in its wider public communication, which are also key to my methodology. In the first two chapters, writing appears that was originally produced for this thesis but that also appeared in other publications during the period of this PhD research. Where relevant, I mention this in footnotes. In the third chapter I describe my methodology for creating and analysing the original practice-based component of this thesis and outline my research questions. In the fourth chapter (my first analytical chapter), I answer my first research question, which is: 1) How do emotions and affects experienced by communicating experts in science communication productions that publics may eventually engage with, shape how they inhabit their roles as communicators? In the fifth chapter (my second analytical chapter), I answer my second research question, which is: 2) How do the emotions and affects experienced by the public engagement practitioner (the producer of the engagement event) shape the outcomes of the engagement event? Lastly, in the sixth chapter, I discuss what I have learned about practice-based research and describe the ways in which I feel I

met my research and practice goals with Aurator's production, as well as where I feel I failed to meet them. In the same discussion chapter, I explore the limitations of engagement methods in public participation settings as they relate to enabling truly emergent, critical debates. Most notably, I review what I have discovered about the function of emotions and affect in science communication. I argue that this knowledge calls upon practitioners to employ a particular ethics of care for science communication in their engagement work. This is followed by a short conclusion.

The empirical data for my investigation consists of participant interviews, process journals, and audio diaries created in this practice-based PhD. I develop a number of conclusions from my observations of the audio diary solicitation process and my interviews with the participants, and argue that collaboratively produced science communication is directly shaped by emotions and affective experiences that emerge throughout the engagement project's making (both those of the communicating experts and the engagement event producer). In my conclusion, I make the case that one of the most overlooked but vital ingredients for ethical science engagement is learning how to *care for science communication* in a way that acknowledges the tenuous, compromising and emergent forms of care that are required differently at differing times when communicating publicly about science.

Science communication is not commonly discussed by scholars or practitioners in terms of personal ethics. Similarly, science communication is not well described in terms of how emotion and affect function in its production. But as the title of this thesis "Listen, why should I care?" hints at, there are many reasons for why we should care about science communication in such terms. The act of listening – to others and to oneself – has been key to understanding the necessity for a personal ethics of care in science communication. This thesis argues that anyone working in the practitioner community, particularly those collaborating with others in their projects, should bear the burden of developing a compassionate, flexible, and response-able personal ethics of *caring for science communication,* where "Response-ability encourages a

practice of making oneself available to respond without knowing ahead of time which phenomena will call one's attention or what form the response should take." (Martin et al. 2015: 635).

Chapter 1: Science Communication

Two anecdotes about the material conditions of science communication

I would like to begin this chapter with two anecdotes that demonstrate two different material conditions of science communication that this thesis is concerned with, those being: the physical setting or surroundings that engagement takes place in and its duration. The anecdotes each sprout from a single event: The International Summit on Human Gene Editing, which from December 1-5th 2015 I attended as a researcher-observer at the American National Academy of Sciences in Washington, DC. Over those three days, I sat in an auditorium and watched an international roster of speakers give talks on the science, ethics, and governance of human genome editing: a type of genetic engineering in which DNA is deleted, inserted or replaced in the genome of a human. The speakers were an internationally assorted group with heavy American representation of scientists, bioethicists, policy experts, legal scholars, and in much lighter weighting, representatives from patient communities, critical race and disability scholars. This particular summit was the first of a series of historical meetings intended to create some form of globally agreed upon expert guidelines for how human genome editing might be regulated around the world. It came at the tail end of a whirlwind year for scientists, bioethicists and the media, that had all been focusing on CRISPR: a relatively new biotechnology claimed to have unprecedented power as a genome editing tool.[1]

[1] CRISPR stands for Clustered Repeating Interspersed Short Palindromic Repeats. It is a natural defense mechanism of bacteria and archaea that allow their cells to deploy "molecular scissors" in the event of a viral attack that can recognize – and cut up- invading viral DNA. In 2012, scientists found a way to use CRISPR to cut any section of DNA they like inside cells with relative precision, not just DNA of naturally invading viruses. The tool can also be used to replace naturally occurring DNA sequences with synthetic DNA, or simply insert synthetic DNA into an organism's genome, allowing it to function as a gene-editor. As stem cell scientist Paul Knoepfler says in his book *GMOSapiens*, CRISPR is like a Swiss Army knife that includes a magnifying glass for finding the right place to cut, scissors for cutting DNA at the targeted site, and a pencil for writing new genetic code in (2015). Scores of researchers are now developing CRISPR techniques to repair genetic mutations that cause debilitating human diseases. But as CRISPR ushers in a

The first anecdote is about the initial moment when I sensed discomfort brewing between one particular speaker and the audience. Earlier that day, we had heard from several well-respected scientists about various gene editing research and how it might be applied to humans for medical effect. Later in the afternoon, were heard from a roster of scholars about the potential societal implications of the same genome-editing technologies that were introduced in the morning's session. During that time, a German theologist took the stage who strongly condemned the use of any genome editing tools like CRISPR to cause heritable changes to the human genome. Such heritable changes could occur by editing eggs, sperm or viable embryos with CRISPR that could give rise to an individual. She saw human genome editing as more harmful than beneficial, and proposed a two-year moratorium on the technology as it could be applied to somatic cells (i.e. non-reproductive cells) until a complete ban on its use in germ cells (i.e. cells that can pass genetic information on to future generations) could be secured. As she said this, I could feel a change in the atmosphere of the auditorium, which was becoming filled with audible gasps and whispers.

She based her argument for a proposed ban on reproductive gene editing on "freedom rights" for future children who could be created with edited embryos, eggs or sperm. From her perspective, the freedom rights of those children would be violated since the children would not be free to be part of the decision-making process about their own genetic modifications. The problem with that, she argued, is that those children become the products of design without any agency to say how they might like to be designed. The resulting children would therefore be subject to other people's values; people who make decisions on their behalf that the children would just have to live with. Would you want someone you don't know to make permanent changes to your genetic make-up, that natural selection had not put there, without your consultation?

---

new era of cheap and easy genetic corrections, some fear it is also rolling out the welcome mat for more dubious uses, such as genetically enhanced humans that have eugenic implications.

The air just continued to be sucked out of the room as she shared more details for her vision of a moratorium. None of the other speakers that day had been so bold as to make declarations about - so far - non-existent scenarios like the ones she imagined.

The next day I found myself sitting on a wine-coloured couch at the far end of a hallway that lay outside of the main auditorium, catching up on some emails between sessions. After I'd nearly finished my coffee and batch of replies, three scientists – each one of whom had already appeared on stage throughout the first two days of the event - started chatting amongst themselves a few feet away from me. I noticed that they were all speaking with an energetic yet snide sort of tone of voice. Due to their close proximity, I could not help but overhear their conversation, which was about the theologist who had suggested the moratorium the day before.

> Scientist 1: "She's a useless woman! She came over to join my table this morning but I had to go eat breakfast somewhere else because I lost my appetite. Honestly, she's bad for you."
>
> Scientist 2: "But the press will love it."
>
> Scientist 1: "We had this with PGD[2]. We had this with stem cells. When Bob did his first IVF back in the sixties he was vilified from the Pope to the President to everyone! He stopped working for two years."

[2] PGD stands for Preimplantation Genetic Diagnosis. First used clinically in 1990, PGD allows for the screening of DNA inside of an embryo before it is implanted in the uterus for gestation (Handyside et al. 1990). Therefore, it relies on in-vitro fertilization techniques, and makes diagnosing genetic diseases in embryos possible before a pregnancy is carried out, so pregnancies that would otherwise create disease-expressing children may be avoided.

Scientist 3: "It's all enabling her. Somehow this is something that is ultimately going to end in…"

Scientist 1: " — it's basic research!"

Scientist 2: "I have no doubt that it will have a place in somatic therapy. There's no doubt."

Scientist 1: "Let's assume it is misused. Let's say it is. We need to know how to deal with the misuse, so we have to do the research! We have to be able to work on it to counter it. So her idea is really stupid, really!"

Scientist 2: "It is a very German way of being."

Scientist 1: "Everything that was first discussed with PGD is now almost discredited."

Scientist 3: "Her solution was…donor sperm?"

Scientist 1: "You know you can do that with a turkey baster!"

(All three scientists laugh and then turn to head back into the auditorium).

Was I really at a historical meeting inside the US National Academy of Sciences and not in the

locker bay of a high school? The disrespect for the theologist that they conveyed felt at once both like gossip and a staple act of teenaged tribe making: vilifying the enemy as a process of building internal social cohesion. As a science communicator, I am interested in finding ways to express how science is a human activity just like any other aspect of culture, and not some infallible objective practice. I've learned over my years of interviewing scientists that a good way to exemplify this is by listening to those who do science when they are defending their practice. In these cases, scientists can act like anybody else does when they feel they're under attack or skeptical scrutiny: defensive, bothered and sometimes, outraged. Scientists, like all people, can get prickly and say petty things. And again, just like other people, their willingness to let those aspects of themselves show depends on the material conditions of their surroundings, which is a theme that I explore in this thesis.

What do I mean by that? Well, for starters, none of these scientists had made personal jeers at any of the stakeholders who may hold opposing views to their own in their presentations on stage throughout the summit. It would not bode well for a researcher from a top tier university to defend their work, ideas, or beliefs in public with jabs of disparagement rather than empirical research. That one of the three male scientists calls the theologist "a useless woman!" - and nobody flinched - strips her of her professional expertise and reveals the mundane way that misogyny can operate in scientific spaces the same as it does out in the wider world. To wit, she is said to be "bad for you," because a woman who is not in service of these scientists' personal values and beliefs is a *lesser* woman. That her "German way of being" is said to be partly responsible for her approach to the controversial topic of making heritable, permanent changes to the human germ line, instead of, let's say, her longstanding research in the area, is a particularly cheap way of erasing her expertise. It is informed by the type of prejudice and personal bias that one may be wary of sharing with "just anyone" for fear of being judged themselves. Moreover, because she suggested that donor sperm could satisfy some of the reproductive needs of parents seeking an element of control

in creating their embryos, they likened it to do-it-yourself insemination methods that involve inserting a turkey baster into a woman's vagina. This was both irrelevant and demeaning, further serving to erase her credibility as an expert, and paint her contributions in the field as equal to primitive reproductive practices instead of valuable research on the ethical implications of state of the art science. These scientists were having fun with each other at the theologist's expense, and they knew it.

When people are personally invested in something, and they put their identities on the line, an ocean of emotional possibilities can emerge. I too have become huffy on occasion when I've felt that my work is threatened or under attack. My purpose in sharing this anecdote is not to point fingers at wrong doers, but to reveal a set of material conditions in science communication that shape what gets communicated: that is, how we communicate differently about science when we are in different settings, with different people, at different times.

Science communication predominantly targets publics, but this aspect of communicating about science, which I overheard, was a covert, private, and self-protecting force. In this thesis, I am interested in the space between the public communication of science and more private forms of it, and the three scientists' exchange highlights the ways that the material conditions of one's setting (where one is, and with whom) shapes the way we take up our roles as science communicators in various forms of public exposure. What would have happened if those scientists had had their same conversation about the theologist on stage in front of the audience, or in an online forum? How would that affect the "global conversation" we were supposedly having about genome editing over those three days?

Is it at all possible that the attitude and tone with which they were speaking would not have to change if their conversation had taken place more publicly on the stage or broadcast live to the internet? Would the credibility of the scientist so disgusted by the theologist that he had to move breakfast tables in order to keep his appetite be threatened if he didn't change his tone? What aspects of his candid

feelings about the theologist's arguments would he have to swallow in public if his objective were to convince us - the audience - to adapt his point of view?

These questions point to a larger issue about how power and persuasion operate in science. As the sociologist Thomas Gieryn has argued, there is always a struggle for credibility in science. "Somebody somewhere seeks to ride science into the public's trust or support or vindication. It is never easy: somebody else challenges their credentials as a scientist, their skills, their procedures, their potential for making a truly better world." (1999: xii). Scientific credibility is always on the line; it is something to be fought for, earned and protected. Rhetoric gets employed to gain it and persuade publics from considering competing points of view. At the gene-edit summit, the theologian's credibility as an expert worthy of scientific influence was up for negotiation depending on who was judging her and how her views served them or not. For if what she was suggesting was indeed the most credible thing to say, then that would mean that those who oppose her would not have credible views. To wit, what was clear in the hallway that day was that the three scientists I overheard shared similar ideas about the credibility of their own positions, which they, due to their significant disagreement with the theologian, did not extend to her work and role. They were performing their credibility in opposition to hers through their mocking tone, comfortable chastising, and "Old Boy's Club" behavior, which came alive when they felt they were alone, but which did not come alive when they were on stage. In other words, it was the performativity of their science communication that changed based on their setting in that place and time.

The second anecdote is about a moment that occurred after the summit was finished. On the last afternoon, I left Washington DC and headed for my hometown of Toronto, where I was happy to see my Dad waiting for me at arrivals hall in Lester B. Pearson airport. On our drive back to his house, I told him all about the summit and what I'd learned there. I remember being clear in my explanation of what the potential therapeutic, preventative and human enhancement possibilities of gene editing

technologies are, while clearly trying to not sensationalize the topic or paint a dystopian picture of where it was all going. I highlighted the need for wide global deliberation around these issues, which the summit was organized in the spirit of. When we got home, my stepmother Nancy Jane uncorked a bottle of wine and we sat down at the table to catch up as a family. But before I had even tasted the burgundy in my glass, my Dad turned to her and said, "You know how we have never really understood what Britt is doing? Well, what she is doing is not only going to change the world, but astoundingly, it will probably allow humans to live forever."

Excuse me?

I was startled. How did he get that from what I had spent the whole car ride home explaining? I quickly tried to backpedal and clarify what "I" was doing. I am not a scientist of course, or at least not any longer, which they know, and I am not doing any genome editing research myself. I am simply studying the discourse around it and trying to understand how it connects to my own field of focus - synthetic biology. It was useful for me to experience my Dad's miscalculation of the research I had described as well as my role in it. It reminded me of John Adams' argument that the primary problem for science communicators is that those receiving the information are not empty vessels into which knowledge can be poured (2011). Adams suggests that knowledge accumulates from information in different individuals in various ways. Their opinions form into beliefs that resonate in correlation with their own subjectivities, values and past experiences that form biases on how they come to understand information. Moreover, those on the receiving end of science communication are always an active part of the information transfer and uptake. Therefore, no matter who the receiver is - scientist or non-scientist - they are never neutral collection plates for information. Rather they are the embodiment of messy, interconnected forces of experience that create their own meaning upon encountering new information through multiple dynamic processes.

Though some force of fatherly pride may have made it easy for my Dad to imagine my attachment to the subject in such hyperbolic terms, the gap between his version of the exchange and mine was telling. What eventually helped bridge the gap was more time for dialogue to discuss our different understandings until they started to meet and make more sense in combination. If I had been a speaker on stage, and he had been in the audience, and that was our only time to transfer information between us (from my speaking to his reception of my words), he may very well have gone home with a completely different view of the issues than what I believed I'd prepared him for. And his perception of my position would likely be something I'd remain forever ignorant about.

Duration, in this sense, becomes a key material condition for the quality of an engagement event. Public engagement about science often occurs in fora that are designed for short-term engagements: places where publics and experts meet only once, even when deliberative or democratic actions are sought from their interaction, such as the Gene Edit Summit, focus groups, and citizen juries. However, as Powell and Colin write, "There is a growing dissatisfaction with the one-off stand-alone nature of public engagement." (2009: 327). When engagement only exists as a one-time occurrence between laypublics and experts, they argue that publics may risk losing interest in the issue or falling off the bandwagon, because they lose contact with experts after some degree of understanding between them had been built (Ibid). Consequently, Powell and Colin question if it is possible to have constructive short-term engagement exercises with a high potential for impact on scientific decision-making between laypublics and scientists. "Most participatory exercises do not engage citizens beyond an event or a few weeks/months, and they do not build citizens' participatory skills in ways that would help them engage with scientists or policy makers independently." (Ibid). This suggests that duration – as a material condition of science communication – can make a significant difference to the outcomes of engagement.

In this thesis, I investigate how the material conditions of an engagement event – such as setting

and duration – as well as how emergent emotional and affective experiences of communicating experts shape how they take up, perform, and resist their roles as science communicators. I also study how these same phenomena interact with the experiences of the public engagement event producer to impact the overall outcomes of engagement, before publics even appear to engage with the science communication initiative. But first, I will describe what I mean by science communication, public engagement, and a variety of the conceptual tools from science communication literature that will be used in my analyses that comprise this dissertation.

What is science communication?

Science communication is often colloquially considered the delivery of science-related information to various recipient publics, usually through methodically crafted discursive texts about scientific knowledge: lectures, scripts, talks, or some other instance of *language*.

Davies and Horst describe the largest uniform model of scholars' collective understanding of science communication as pertaining to the idea of information that is "travelling" or being constructed between at least two different groups (2016). Normatively speaking, this occurs between science experts and lay publics. They define science communication as: "organised actions aiming to communicate scientific knowledge, methodology, processes or practices in settings where non-scientists are a recognized part of the audience." (2016: 4). They describe it as taking place in many forms, which are increasingly expanding, through design for different audiences that is both conscious and unconscious. It gets consumed formally and informally, in daily life scenarios, such as an opportunity to present one's research in a board meeting or the act of encountering environmental-activists on the street. It includes diverse – and growing - platforms such as Facebook pages, government consultations, television programs, science cafes, science slams, medical pamphlets, entertainment festivals, museum events, after school activities, and much more.

By virtue of its ever-growing diversity, I also consider the two anecdotes I already explained (at the gene edit summit and in the car with my father) to be daily instances of how science communication can take place.

Importantly, there are *reasons* why people communicate about science. Science communication has *purpose.* Though the reasons are not uniform, there are always things that communicators may want their science communication *to do.* Gregory and Miller outline a manifesto for science communication in their book *Science in Public,* and write about the heterogeneity of its purpose: "The purpose of a science communicator may be to empower its recipients, to enhance existing democratic processes, to help develop new ones where such processes do not exist, or to prevent the alienation of sections of society; but it may also be to serve the interests of the scientific community and its paymasters." (1998: 245). Some may choose to communicate science because they feel it is particularly complex and requires explanation, or because they believe it will weaken the potency of fake news in society. Durant et al. identify additional reasons science communication may take place, describing: science as a *cultural achievement* that laypeople would enjoy knowing about; science as a powerful institution that may *affect people's lives;* and science as a public good that taxpayers fund, which they deserve to understand (1989). Science communication may also be motivated by power. Corporations and nation-states have something to gain - or lose - in the race to an increasingly technoscientific future; which may be attained to different degrees depending on how the research attached to its vision of the future is publicly discussed.

The development of a critical scientific citizenry that is aware of the complexity of scientific issues is one crucial purpose of communicating science, but as Gregory and Miller's manifesto suggests, it may not be the sole impetus. There are things at stake for diverse agents beyond the "good" citizen and science communication may not always be motivated by ideals of the responsible social life. For example, some science communicators, which I count myself amongst, do not ever aim to directly influence policy,

governance, or a voter's opinion with our work. Instead, we engage with science for the sake of it: for its beauty, its fun, or its fascination. Engaging with science communication for enjoyment is a theme that this chapter will explore.

Science communication is not novel

Communicating science in public through popular or accessible platforms is nothing new; the concept of "science in public" has been part of public life since the beginning of science itself. Gregory and Miller have shown that popular science dates back to several ancient examples, including ancient Egypt, when Herodotus (c. 484-425 BC) granted public access to the explanations that were given by Nile priests to describe how silt deposits from the river made the geology of the region. In 1543 Copernicus published *De revolutionibus orbium coelestium*, which, it could be argued, was written for the public. And when the Catholic Church condemned Galileo of crime, it was not because he espoused the heliocentric model, but because he had *popularized* it (1998).

Their book *Science in Public* tells how the exploration of scientific controversies in popular media is also not a recent phenomenon. The New York Times and Harpers Weekly reported heavily on the technological competition between Tesla, Edison and Marconi in the 1890s. The public reception of Rontgen's discovery of X rays in the same decade was sometimes very critical, and ignited a public opinion that "scientists boast too much" about their own personal inventions. (1998: 25). A hoax took place in 1835 that poked fun at the serious tone that the scientific institution expected publics to receive its messages with, when Richard Adams Locke wrote a series of front page stories for the New York Sun about how John Herschel discovered unicorns and winged people on the moon (ibid).

Throughout history over centuries, publics have been – and have continuously become - routinely asked to engage with risky technosciences while they are still emerging (ibid). Risk in science

communication has often been tied to the possible future states that technoscientific projects propose, and stock examples of new and emerging technologies that pose such risk include nanotechnology, geo/climate engineering, even the topic of this thesis: synthetic biology. But while spaces are made to talk publicly about scientific risk, the types of conversations that can take place in those spaces vary, because engagement experiences may not always be as accessible, open-ended or as critical of science as they are intended to be (Delgado et al. 2011). When publics and experts are discussing risky technologies sincerely, it is beneficial to be able to have honestly open and critical discussions. As a field, science communication has been telling a story about itself in terms of how it has grown better at creating spaces to have those kinds of discussions through evolving iterations of public engagement models.

Deficit to dialogue

Many scholarly accounts describe public engagement's contemporary form as finding its origin story in 1985 upon the publication of a document called the Bodmer Report (Bodmer 2011). The Bodmer Report, which is part of a specifically British history, announced a crisis in the "public understanding of science" (hereafter PUS) that triggered interest in the creation of organized efforts to combat it. Based largely on public surveys, it identified problems with what it called "public attitudes" to science, and noticed a lack of understanding on behalf of the public to understand things like statistics in risk assessments, and basic facts about objects of scientific study such as planets or nutrition. What followed was a particularly active late 1980s and early 1990s that aimed to increase the scientific literacy of the public. The idea that a group of specialists can target a group of "ignorant" or less knowledgeable publics on a scientific topic that they have expertise in - in order to increase the publics' knowledge and perhaps even appreciation of science - is the logic that drives what is known as the "deficit model" of science communication. In this model, information has been identified as lacking, and it needs to be filled

in. The assumption was that once the gap is filled, the newly knowledgeable publics become understanding of science and therefore more appreciative of it.

But scholars have shown that this one-way, top-down model of information transfer, from expert to layperson, did not have the simple effect of increased knowledge some hoped it would (Irwin and Wynne 1996, Trench 2008). Publics across the board did not automatically absorb – or love - the science they were learning about. Some were increasingly weary of it and mistrusting of specialists who fed it to them. At the same time, the very essence of the concept that knowledge could be injected from the minds of specialists into those of publics was rightfully questioned. The idea that publics remain open and available for whatever information flows their way does not acknowledge the processes of construction that are always a part of a communication experience. The lecture, newspaper column, film or other form of messaging is always interpreted by the receiving public, and in that sense, is always co-produced. Therefore, deficit models do not always hold up.

Furthermore, Alan Irwin argues that individuals make sense of science in a context-dependent way (1995). They attach it to their own lives and explore what it can do for them not based on knowledge but based on how it connects meaningfully to their normative context. This is what Irwin calls the construction of a "scientific citizenship." It is shaped by everyday lives, pre-existing knowledge and people's individual experiences, values and beliefs.

Similarly, as I briefly mentioned before, John Adams argues that the primary problem for science communicators is that those receiving the information are not empty vessels into which knowledge can be poured about issues pertaining to science, and especially uncertainty, where things are at stake. (2011). Instead, recipients rely on their own personal biases and knowledges in order to parse meaning from new information. Therefore, he suggests, "Perhaps the best that a science communicator can hope for is that introspection might assist recognition of one's own biases, and an awareness of the inevitability

of different biases in others… Self-knowledge and an ability to stand metaphorically in the shoes of others are key ingredients of the empathy essential to effective communication" (2011: 100).

When critical scholarly readings of the deficit model started appearing, researchers' understandings of how various publics engage with science began to shift from a deficit to a dialogue model, whereby scientists and their publics engage back and forth, fueled by an ideal of democratic dialogue, to air their interests and concerns. This two-way model of communication started to outmode the idea that one-way communication, directed from specialists at publics, was worth pursuing. By the end of the 1990s, the new awareness of the problems found in deficit approaches evolved into the call for "Public Engagement with Science" (PES) rather than "Public Understanding of Science" (PUS) (Durant 1999). Initially PUS only served to re-divide science and society by highlighting widespread public ignorance of basic science knowledge amongst everyday citizens in "advanced" societies. PES was now focused on bringing science and its publics into close proximity, through dialogue, after seeing the lack of confidence that the public had in science as the main issue of concern. (Irwin and Wynne 1996; Elam and Bertilsson 2003).

And so, a narrative has emerged that tells the story of the rise of science communication from a less sophisticated mode of information delivery to a more sensitive and nuanced dynamic of engagement between specialists and laypeople (Horst and Davies 2016). As Brian Trench plainly states, "Science communication has been telling a story of its own development, repeatedly and almost uniformly, for almost a decade." (2008: 119). The narrative of deficit to dialogue has been important, and helpful, for science communication scholarship to keep track of itself and explain to others what it has been doing. It is central to the thinking of those who study it, and those who produce it. But this espoused progression - from deficit to dialogue - does not always account for what happens in reality, for deficit models are still

exercised by science communication practitioners and deficit approaches may at times even be beneficial depending on the communication goals.

Other models of science communication

The deficit to dialogue story is so familiar in science communication scholarship that it sometimes masks other models that can help develop a further description of what's happened in the field. Alan Irwin nuances the story of deficit to dialogue in a chapter called *Risk, Science and Public Communication*, where he makes three distinctions between commonly found approaches to science communication: first order, second order and third order. These distinctions, he argues, can exist together, fold in on one another, and even occlude each other (2014). He shows that 'first-order' (or deficit) models of science-public relations eventually shifted into a system with greater emphasis on public engagement and dialogue, which he classifies as 'second order.' From there, 'third-order' is classified as 'thinking about risk, science and public communication that asks fundamental questions about 'first-order' and 'second-order' approaches, the changes that have taken place (both in theory and practice), and the future direction of scientific governance and science communication.' (ibid: 199). Therefore, 'third order' thinking urges one to consider the multiple potentials for personal and political activity in science communication: "new possibilities emerge for forms of communication that do not simply trade in the unreflexive language of deficit and dialogue, but that open up fresh interconnections between public, scientific, institutional, political and ethical visions of change in all their heterogeneity, conditionality and disagreement." (ibid).

Sometimes recognizable features of the deficit model are referred to in the literature as the *diffusion model*, that is, a model that espouses knowledge and information about science gets diffused from scientific experts and institutions via some medium outwards to audiences that will absorb it (Rogers 2010). As I already mentioned, critical PUS pointed out that the problem isn't so much that the public doesn't

listen to science, but that science doesn't understand how publics make sense of scientific information and generate meaning from it in the many heterogeneous forms that they do. The scholarly criticism of this model led to a new model – the *deliberation model* (which we might otherwise recognize as "dialogue") - where public audiences share their thoughts, ideas, experiences and knowledges about science back to the scientific bodies that normally do all the talking in the diffusion (or deficit) model. This deliberation model portrays a two-way transfer of information between science and its audiences, to ensure that science and scientists act in accordance with society and its values (Horst and Michael 2011).

After outlining these two models (diffusion and deliberation) in the article *On the Shoulders of Idiots: Re-thinking Science Communication as "Event"*, Horst and Michael offer a third, new, model of science communication – one that has been formative to the development of my thesis and that will reappear in these chapters. They argue that this third model– the *emergent* model – doesn't merely count the transfer of information back and forth along directional lines, but that it is "a constitutive force in shaping entities such as science, publics, and society." (2011: 286). This emergence model of science communication shapes those entities, they argue, according to the specific parameters of a science communication project on temporary terms. An important difference of the emergence model of science communication compared to the first two (diffusion and deliberation) is that it does not privilege the direction of information flow, nor does it privilege any stable medium through which communication allegedly happens. Importantly, their work shows that the substance that mediates information and value transfer about science in the emergence model is an unstable process, because "the entities themselves are seen as mediators, that is, as actants who change, and are changed through, the event of coming together." (2011: 86). It calls for a rethinking of science communication and the dynamics at play in site-specific cases. The emergence model urges us to think about the specific actants, materials, and societal conditions at the engagement site that will inherently be constitutive of the communication that's happening. I am

particularly interested in this model because its openness and non-uniformity allows me to notice and describe how the material conditions of site-specific engagement, such as duration, surroundings and emotions affect how participants engage with the process of producing science communication when they come into contact with other communicators or engagement event producers.

Another, different model of science communication comes from Alfred Nordmann, who argues that after all of the strenuous criticism of the deficit model in science communication, we've come to arrive not at a deeper and more reflexive model of rigorous engagement, but at a *surplus model* that is too sophisticated for its own good (2011). Nordmann says that our efforts to improve our past "wrong doings" have resulted in an over production of science communication formats and frequencies that are propelled forth to publics in a fashion that has weakened the whole effort (2011: 101). This critique is further developed by Helga Nowotny, who argues that we began with a deficit model of science communication that was "cheap" to produce because it merely aimed to fill in the gaps of knowledge for publics, but it was "expensive" to make sense of for publics who had to learn from it, and then make up their minds on particular issues with their newly bestowed knowledge. But according to Nowotny, as science communication's reflexivity grew, and deficit approaches were critiqued, the field moved into what it has now: "expensive" science communication. This is sensational science communication: big-budget festivals, wonder-filled documentaries, interactive museum exhibitions, immersive experiences and more that have extremely high production values. The problem about this, for Nowotny, is they tell stories that are all too easy to grasp. They are "cheap" to comprehend and don't ask much for the public in terms of their own analysis. They are designed to be quick to consume, like science communication snacks. The problem here is that science communication becomes more *sexy* than *successful.* In other words, the model has become inverted (2005).

There is no perfect model to sum up what science communication is, or exactly how publics

engage with it. Attempting to grasp it with a particular model, analytical lens, or narrative will only bring trouble. There will inevitably be overflows and inconsistencies. Similarly, for those doing the communicating and engaging, their reasons for participation can vary, overlap and compound each other. Therefore, it is not helpful or even possible to essentialise the reasons why people engage with science communication. This ambivalence is what makes it an interesting and fertile space to conduct new experiments in, which this dissertation will explore in my account of a personal investigation to try and create a novel format for public engagement about synthetic biology.

In this study, I am interested in modes of science engagement that publics can experience while being allowed to check their "democratic responsibility" to weigh in to institutional powers with an opinion or vote on a policy, bill, funding decision, and so on at the door. In this sense, I am focused on science engagement events that may be worth participating in for their emotional or affective qualities alone, that can generate personal feelings and reflections in the person who experiences it. Therefore, I situate my own practice-based public engagement research in the "non-policy informing" domain of science communication, which I will shortly describe. But who is it that such public engagement projects are trying to reach? For that, we must grasp a better understanding of who constitutes a target audience for science communication in the first place.

Publics

Colloquial connotations of "the public" paint it as a monolithic block of people who are somehow "members of society." But a singular public does not exist, and "publics" are hybrid communities that are always "on the move" in their potential to become part of yet another form of public. (Bennett et al. 2011). The individual qualities of different publics – which vary greatly in terms of their interests and experiences

- bear meaning for how knowledge will be received, processed, responded to and formed according to the personal biases, knowledges, and preferences of publics.

Latour and Weibel problematized the idea that there is a unified public "out there" that is *hermetically sealed off* from specialist communities, with whom good scientists and science communicators should aim to engage (2005). Are scientists not a member of the public too? And do they not belong to multiple communities that could be deemed "the public" depending on where they find themselves and when? Could they not at once be part of a voting public, a public audience, a public supporter, and a representative of the public in domains pertaining to entirely different issues? Importantly, critiques of the specialist/public divide make the important point that specialists are indeed constitutive of "the public" themselves. Publics are diverse collective entities that have overlaps of membership and are always, in part, characterized by their context. Irwin and Michael suggest we should think of publics as:

> "Products of contexts: the same individual can assume different roles at different times (or at the same time), so the same individual may behave differently as a member of the citizenry or the community of consumers, as 'users and non-users' of technology, or as a member of some organized interest. In other words, publics are a complex and heterogeneous set of actors and relations that arise from particular contexts." (2003: 175).

To treat this suggestion seriously in public engagement means that publics should not be taken for granted as collectives that can be fully grasped, examined, and known. They vary in time, place and concerns, and are susceptible to being imagined by others as related networks – as caricatures of communities - when in reality they may not be (Bucchi and Trench 2008). However, publics are also not simply self-given entities that maintain their identity by virtue of the people comprising them. They are phenomena that get produced – and become made – through processes of their participation in various engagement settings.

Machineries for making publics

Science communication researchers have studied the processes by which publics get made based on how they take up, resist and transform their participatory roles. For example, scholars have shown how the design of a public participation experiences can work as 'machineries' that socially and materially construct certain type of publics (Braun and Schultz 2010; Felt and Fochler 2010) and certain type of citizens (Irwin 2001). Some of those studies, particularly Felt and Fochler's, have inspired me to explore how other people who are also involved in an engagement event, but who are not normatively considered to be part of its targeted publics can also be shaped by their processes of engagement acceptance, refusal, and transformation. These people can include communicating experts who may lend their scientific knowledge to an engagement event, or even the engagement event producers themselves. I'll elaborate on why this is in my methodology, but for now, I would like to flag to the reader that this section will prove material to how I analyse my study in the chapters that follow.

In the article *Machineries for Making Publics: Inscribing and De-scribing Publics in Public Engagement*, Felt and Fochler take it for granted that engagement is a performative act as they investigate how publics take up and inhabit their role as participants in engagement fora, and see themselves in relation to wider publics, by studying four engagement events in Austria. Their research shows how temporality – as a material condition of the engagement events - has major effects on the engagement outcomes. This happens, for example, through the way that participants understand how much time they have to engage during a participatory event. This perception changes the outcome of their participation whether the available time is seen as a scarce resource and therefore needed to achieve a specific defined goal, or whether the remaining duration of the exercise is seen as open for reflection and emergent outcomes. For example, in one of their case studies, they discover that "the participants of the citizen conference were so clearly devoted to working towards a specific aim that they even perceived dissent and debate on ethical

issues as ineffective use of their time, as opposed to 'gathering facts' to be used in the final statement." (2010: 231).

According to Felt and Fochler, machineries for making publics are the processes by which publics come to inhabit their roles as engaged participants in different ways, which they argue, can be understood by using Akrich (1992)'s study of how designers imagine an object and how it will be used when they "inscribe" their vision of the world in the physical design of the object. "Inscribing" happens when the designer creates an object through a particular worldview "with specific tastes, competences, motives, aspirations, political prejudices, and the rest, and assuming that morality, technology, science, and economy will evolve in particular ways" (Akrich 1992: 208). Through the process of "inscribing" an object, a "prescription" is made for how to use that object according to all of the value judgments that went into designing it. A "prescribed" object is an object that others may use in the way the "prescription" guides them to, or they might resist the "prescription" altogether, and create some new form of use that the designer didn't imagine in their "inscription" of the object. When this happens, the object gets "de-scribed" by the users' subversion of the designer's vision and framing for the object. Applying this concept to the study of participating publics in engagement formats, Felt and Fochler write, "Participants might have very different ideas about the technology, the world inscribed in it, and their attributed roles. They might struggle with, attempt to shift, or to even reject the script – hence describing the technology." (2010: 220). Therefore, the performativity of participatory engagement events can only be understood by considering both the design of the engagement, and its actual uptake by participants.

Science communication as public engagement

It has been argued that public engagement's unique framing, which separates it from being totally synonymous with science communication, was motivated from a consciousness that rose with the

recognition of a need to move away from a PUS approach towards a PES model (Davies 2014a). As the story goes, PUS transitioned towards PES, with a larger focus on scientific governance, the term started to generate more steam. Public engagement is generally seen as valuing the democratic process as its first priority, and so emphasizes two-way or multi-way discussion, public involvement and responsive policy-making (Bucchi and Trench 2014). Therefore, public engagement is often connected to events that take place in institutional fora that practice forms of deliberation. The outcomes of deliberations from public engagement activities can then carry over into decision-making settings that have relevance for governance.

A wide variety of public engagement formats exist that are meant to have some influence in processes of governance of the science being discussed. These can include formats such as focus groups, citizen juries, consensus conferences, stakeholder dialogues, internet dialogue, deliberative mapping, among others. The list is by no means fixed and is growing all the time. Public engagement is therefore heterogeneous. It includes communication events that create the opportunity for agenda-driven deliberation and non-agenda-driven deliberation, where agendas can be understood as connected to the desire to inform policy and governance.

Non-policy informing public engagement

Public engagement activities often aim to open up deliberation for democratic purposes, and scholars have shown that when they fail to do so successfully, attendees can end up feeling frustrated and unfulfilled (Delgado et al. 2010). But what about public engagement that is not aimed at using dialogic platforms, media and formats for the sake of informing policy or governance? What about projects that engage just because they want to? It is not only the divergent goals of public engagement that contribute to feelings of disappointment that may arise, but the divergent forms of expectations that publics bring into participation fora. Therefore, it is not surprising that participants sometimes leave an engagement event

feeling disappointed, depending on what their personal expectations were walking into it (Horst and Michael 2011).

Engagement projects can vary in their goals, and also their needs. Some public engagement projects that seek to engage publics for the sake of engagement itself do not aim to travel any further than the room, computer screen, festival, or bar that the actors who are engaged with it are in. In this thesis, I seek to create an engagement experience for publics with my research that is worth exploring for its own sake as an intimate and affecting project, which will be elaborated upon in my methodology. However, if publics choose to use the experience of interacting with such an engagement event to help them inform deliberative decision making, then of course that is not something I can – or particularly care to – control.

In recent years, it has become increasingly common that public engagement is pursued for the fun of it. Science slams, science cafes, comedy shows, theatre performances, interactive art, design fiction, and biohacking events increasingly contribute to the evolving science communication scene. Noting this, Davies et al. draw a distinction between "policy-informing" and "non-policy informing" public engagement (2009). These mostly non-policy informing formats are often experimental, open-ended, and cultivate the sense that public debate about science need not be justified by thinking about governance or responsible risk assessment. Another example of non-policy informing engagement would be educational engagement in schools. Reschly et al. argue that adolescents' levels of engagement in school tends to increase when positive emotions are frequently stirred up in class, as compared with the frequent propulsion of negative emotions, which can significantly reduce the level of student engagement. In other words, there is a relation between emotions, their kind, and the quality of engagement a student may have, which bears importance for how they learn and achieve in a non-policy informing engagement setting (2008).

The types of activities that take place in both "policy informing" and "non-policy informing" engagement are wide-ranging and evolving, typically involving face-to-face encounters between science experts and publics. Their live nature means that they are participatory in essence, where people can pose questions to one another and articulate their own thoughts through emergent conversations. As a result, public engagement events often serve as collection sites for wider reflections on the relationship between science and society at any point in time (Davies 2009).

Embodiment and materiality in science communication

Science communication scholars have been criticized for overlooking the affective dimensions of engagement. Sarah Davies has argued that science communication scholars focus too narrowly on the discursive elements of science communication despite the growing existence of sensory information that gets transmitted in many science communication and engagement experiences, such as interactive exhibits and dramatic science productions (2014a). "Discursive" in this context, refers to the written and spoken word, or "language in use." Davies challenges the idea that the potential impacts on the participants from a science engagement experience depend solely on the "language in use" in that activity. Instead of limiting themselves verbal and written phenomena, she urges science communication scholars to shift their gaze to the importance of site, embodiment, materiality, and affect in understanding how science experiences make publics feel in the moment as well as afterwards—including a consideration of how such materiality affects how publics come to feel about science itself.[3]

"What makes science worth engaging with?" Davies asks. After all, non-experts have busy lives and myriad other interests. Then, she attempts to answer her own question:

[3] This section and some of the immediately following text is taken from my writing that also appears at Wray, Britt. 2015. The Evolving Culture of Science Engagement. Accessed December 6 2015. http://www.cultureofscienceengagement.net/blog/2015/2/2/guest-post-embodying-engagement-with-science

> "People (whether scientists or laypeople) generally participate in public engagement because they want to—because they find some satisfaction or enjoyment in talking about nanotechnology at a museum forum event, experiencing the spectacle of the Body Worlds exhibitions, or participating in a policy-oriented discussion. There is, we might say, *a hedonism of science* as leisure and pleasure, and it is this latent and largely unacknowledged reservoir of emotion that powers many of the encounters between scientific knowledges and publics." (2014a: 101), (italics added).

But using pleasure as the lens through which we evaluate the worth of a science engagement experience introduces an important issue. This can reinforce the old idea, worthy of criticism, that knowing more about science leads to loving it: that knowledge precedes and *causes* interest and connection rather than the other way around. Contemporary science engagement is much more complex than that simple tenet suggests. The idea that science communication is something people can *love*, and can by extension be trained to love, smacks of getting people to love broccoli. It arguably has many beneficial properties, but not everyone takes a natural interest in it. Some want it every day, some never, while others ebb and flow depending on the setting, occasion, and social context. In our everyday lives, we regularly laugh at things and feel emotional about ideas or subjects that we don't necessarily "love" or identify with. Indeed, it can bring us a lot of personal satisfaction to engage that way, without leading to some kind of further behaviour or change of heart. Similarly, audiences can feel all sorts of things about science, appreciating their experiences of contact with it beyond binary feelings of good or bad. Davies argues that the gulf between *exposure to science* and *loving science* is worth exploring.

> "Many scientists do think that interested publics will like science better, and become a more accepting market for its products (or perhaps be recruited into it). But is this dynamic the only one structuring expressions of interest, pleasure and delight? Can we understand them in any other terms? I would suggest that pleasure in public engagement is indeed a more complex phenomenon—one that requires further attention in order to account for and understand its role and meaning." (2014a: 101).

This suggests that scholars should look at the everyday experiences that breed identification with and interest in science, and learn what (if anything) flows from those experiences over time. As Davies says, "It

is precisely when science is not taken too seriously that engagement with it becomes powerful." (2014a: 102). Which leaves me wondering: Must we become "science lovers" for the impacts of engaging with science to be powerful in our lives? Or might we be swimming in a whole other ocean of emotions and affects, yet to be fully explored?

Emotion and affect

It is crucial to make it clear that I am not interested in contributing to affect or emotion theory with this thesis. That would be an altogether different undertaking from what I am doing here, which is: contributing to an understanding of how participants' personal feelings impact the way that science communication gets produced. Feelings can be understood in terms of emotions and affects, which I will explain. However, the fact that they are emotions and affects is not what is most important; it is more important that I pay attention to the personal experiences a participant feels or communicates which are energetic intensities that can cause something to happen in a process, such as the practice of making science communication. Emotion and affect theory help clarify the way these intensities can be recognized, which is why I call upon a limited subset of the available theory on emotion and affect in my research. However, theory on emotion and affect is a supporting boon to my argument rather than a home for it. Now that I have delimited my study to explain to the reader that I have only sought an understanding of how emotions and affects function as *feelings* that can *make a difference* in what happens in a given setting, I can clarify how these terms are framed in my mode of inquiry and embedded within select definitions from the available literature on emotion and affect, which will appear here and later throughout the thesis.

Affect is often misunderstood as being synonymous with emotion. However, some have described affect as something that can be sensed and experienced as intensities in an embodied way at an individual level (Massumi 2002). In this definition, affect is a precursor to emotion and can lead to

emotional experiences, but is not the same as emotional experience. However, not all definitions of affect in the literature line up. The *Oxford Dictionary* defines "affect" as "to touch the feelings of; move emotionally" and as "emotion or desire as influencing behavior". In another definition, Margaret Wetherell outlines affect as operating on two different levels: one that directly relates to familiar emotions, and the other that roams more broadly into wilder spaces where some type of influencing force or intensity *makes a difference* (2012). If one were to study the first level Wetherell identifies, they would see emotional states and the movements they cause in the body and mind. This includes every aspect of recognizable emotion (for example anger, fear, happiness, etc.) and also considers bodily perturbations such as blushing, arousal, tears, and associated brain activity. If one were to study the second level of affect as Wetherell describes it, they would see much more general movements, influences and changes in an individual. To be affected by something in this second way is based in phenomena we know from myriad aspects of daily life. For example, your parents affect the way you are brought up, and hunger affects your mood. To be affected therefore is to be touched by a force – *an intensity* - that causes something to happen. The force may also be mysterious: you can be affected by a play, causing something new to happen in your mind or body, but you may not understand exactly how it affected you.

Both levels of conceptualizing affect, as Wetherell defines them, focus on embodiment and investigating how influences on behaviours, attitudes and thoughts get made. Therefore, affect can be located in subjective experiences that we have clear vocabulary to describe, such as discrete emotions or sensations, while at other times it is situated in less-nameable intensities that cause something to happen, but evade specified articulation. Wetherell's definition of affect is helpful to me in how it describes emotion as a type of affect (layer one), and therefore mobilizes both terms of *emotion* and *affect* in the same concept, simplifying the way it can be identified in data. Any discrete emotion becomes an instance of affect, while so do more generalized but nonetheless *affecting* forces.

For my purposes here, I look at affect as the general process of *making a difference* and I use Mary Wetherell's descriptions of how affect functions as my guiding principles on the concept. Importantly, her dual-layered definition encapsulates emotions and sensations (layer one) as well as more general impulses (layer two). Rather than dive into the rich and complex literature on what emotions and affects are, I operationalize Wetherell's encompassing concept of affect in order to recognize where it appears in my study. This is what my study requires: a tool for identifying instances of affect and emotion so I may analyse their function in the process of making science communication. Anything more theoretical than this would be superfluous for my task.

Much of the science communication literature that relates to *affect* pertains to Sarah Davies' research, which I've written about above. But there are also other examples of studies that deal with public participation and emotion. Hoggett and Thompson's work on citizen juries shows that emotions are always present in deliberative settings even though in principle, deliberative processes are supposed to be impartial (2002). They argue that impartiality is an impossible goal to attain in deliberation practices because humans are made up of various identities, biases, values, experiences and beliefs. "In practice, emotions such as fear, hatred, and cruelty, as well as compassion, remorse, and grief, often undermine commitment to impartial principles of deliberation" (Hoggett and Thompson 2002: 107).

In another example, Matthew Harvey criticizes deliberative public participation events for omitting such emotions from their evaluations (2009). According to Harvey, the normative qualitative and quantitative evaluations that are made after public participation events such as the UK "GM Nation?" public debates, which took place across the United Kingdom in the summer of 2003, are deficient in two respects (2009). Firstly, the evaluations of those debates omitted the importance of the dramatic and emotional experiences participants can have when engaging with experts on a controversial topic such as GM crops in participatory events. Secondly, the evaluations omitted the importance of *what actually happened*

in terms of the participants' actions while they were engaging and how those experiences shaped the outcome of the participation event. Participatory experiences in the "GM Nation?" debates were sometimes very uncomfortable and emotionally charged. Harvey gives an example of a debate when the emotions being communicated were adversarial in nature, causing people to remain quiet and participation to shut down. As Harvey recounts, "a participant (F2) in the audience sitting just behind me was visibly crying as he or she made a point to a pro-GM farmer on the panel (GS):

> F2: I apologize in advance for this, this rather emotive and emotional question but as you see I'm in quite an emotional state. This is to [GS]: Have you spoken to the farmers who have committed suicide because they couldn't afford seed next year because they're so tied into Monsanto's GM-dependent system? Have you spoken to them huh?
>
> GS: No I haven't.
>
> F2: That's because they're dead.
>
> GS: Farmers aren't daft; they don't sort of give up their independence willy-nilly; they make decisions. Farmers across the world have a simple choice: they can grow GM seeds, or they can grow non-GM seeds." (2009:157).

Harvey goes on to explain that out of the 130 people who attended that meeting, very few spoke out. They chose to remain quiet throughout several opportunities they had to ask questions and make comments during the meeting. However, Harvey noticed that it was during the coffee break when one of the

participants who had otherwise been totally silent expressed that she didn't know if she could trust the data that was presented by the experts on GM so far (ibid). This would have been an appropriate comment to make in the meeting to the experts in the room, possibly eliciting helpful feedback. However, people in the room were palpably "worked up" and "emotional," creating an intimidating and perhaps too intimate atmosphere for participation. In this way, emotional and affective experiences can play a role in what happens between publics and science. Public interactions with science in engagement settings can therefore be shaped by the quality of emotion and affect in the participatory event.

Harvey shows that engagement fora are sites where values, beliefs, agendas, and decisions are co-constructed by participants, and that emotions materially influence the way that co-construction happens. However, at that particular "GM Nation?" debate, emotional elements weren't accounted for in the debate's evaluation. Importantly, as Harvey argues, emotions have a material effect on the outcomes of engagement, and should be considered in evaluations of public participation events. Similarly, science communication scholarship has some blind spots when it comes to how it treats the function of emotions (affects) in settings where science communication is being produced. This is a gap I seek to make a contribution to. It is worth noting that since Harvey published in 2009, more evaluative studies that assess the "success" of public participation events include a cognitive assessment of participants' emotional responses (Jensen and Buckley 2012).

Other scholars have added to this body of work that seeks to understand how the material non-discursive sites of engagement – like emotion and affect - shape public engagement experiences (Davies and Horst 2016). The tendency for PEST (public engagement with science and technology) research that concerns itself with emotions has been to study how the emotions of publics who engage with science affect how they perceive science (Roeser 2012). Researchers have argued that science communicators need to engage civil society at the level of their emotions by taking their feelings seriously

in engagement contexts if they care to get any real indication of what matters most to publics about scientific issues (Sleenhoff et al. 2002). Copious public perception reports exist about controversial technologies, including synthetic biology, which divide publics according to their emotional responses to what certain technologies can do, or feelings towards any ethical issues that the technologies raise (Mandel et al. 2008).

In the context of public participation for social movements, Barnes has argued that there are affective and emotional dimensions to making decisions in deliberative settings because these decisions are usually guided by personal values and experiences that motivate someone to participate, and are attached to some kind of moral reasoning (Barnes 2008). Deliberative fora therefore should not be thought of only as spaces where "reasoned argument is intended to lead good policy making." (2008: 461). Barnes considers them "spaces in which identities are negotiated, constructed and possibly transformed, righteous anger, pain and frustration are expressed, and hopes and aspirations are pursued." (ibid). Participatory governance models therefore create opportunities for "passionate participation" in spaces that are made up of people's emotional experiences and expressions. As a result, Barnes argues that deliberative processes in participatory governance must be capable of containing, acknowledging, supporting and valuing "emotional morality".

Marks and Russell (2015) take Barnes' point into a bioscience setting to argue that we should go beyond thinking about discussions of science and technology as "hard" processes with objective domains. Instead, they suggest we make space for valuing the emotional and affective domains of making decisions about science and technology that are shaped by people's values and experiences. Truly valuing emotional morality in deliberations about science and technology, they argue, requires a practice of *care.* They identify care as something that engagement practitioners are already busy doing in their work when

they create safe spaces for publics to congregate and explore issues of emerging science and technology. Considering an example of a synthetic biology engagement event in Australia called STEP, the authours write of the engagement practitioners: "They create a new atmosphere with their ice-breakers, post-it notes and world cafés, and even more importantly with their warmth…these practitioners brought care and an invitation for participants to care." (Marks and Russell 2015: 107).

Furthermore, the engagement practitioners were attentive to power imbalances in the field of synthetic biology (such as the fact that sociologists and synthetic biologists experience power asymmetrically in interdisciplinary knowledge networks, which I will explore in the next section and the next chapter) as well as discursive matters of concern (such as that members of the public are sometimes imagined, uninvited or mistaken for different kinds of social researchers in synthetic biology engagement settings). With this attention, they then administered an ethics of care by creating additional spaces during the engagement event where the sociologists could meet together and discuss their matters of concern without having to be anxious that they would be spoken-over or misunderstood by the synthetic biologists in the room. They could also voice their frustrations about being fed up with the scientists not taking their critical remarks into consideration, and then anonymously feed those frustrations back into the multi-stakeholder engagement settings during the engagement event. The practitioners also invited lay members of the public to discuss their thoughts and concerns in spaces where scientists were not present, to avoid situations where scientists might shut down their attempts at asking broad ethical questions. The authours write "care, and the persistent and patient tinkering that comes with it, can transform both the practice and experience of public engagement, recognizing that engagement is a situated and transient process and therefore must always be nurtured." (2015: 111). This concept of care is central to my project, which I will develop much further in the discussion (chapter six) of this thesis.

Issues of identity and their effects

A sub-field of study within science communication, referred to as "the science of science communication" or "cultural cognition" looks at how the values and personal beliefs held by specific publics are key to determining how those publics understand and respond to controversial scientific issues. Researchers have found that they tend to respond along partisan lines or according to their own personal-identity subgroups (tribes) (Kahan et al 2009, Kahan 2013). Cultural cognition tries to assess how various publics can look at the same scientific data and come to different conclusions on it. Conclusions about data in science communication contexts get based more on the receiver's cultural disposition and identity than by any cognitive processes that openly consider what the data has to say. Emotions strongly reinforce how one supports their group identity by construing data to support that identity (Kahan 2010).

Another example of how individuals' identities become entangled with science communication can be seen where different disciplinary identities get combined in designated interdisciplinary knowledge networks in the name of "responsible research and innovation." Ana Viseu writes about her experiences as an embedded social scientist in a nanotechnology research department at Cornell University over three years. She was invited to situate herself in that department based on guidance from science policy that highlights the need to integrate the social sciences into the research and development process as early as possible in order to maximize social benefits and reduce possible social harms and controversies; a major tenet of "responsible research and innovation" (2015). However, there is a major tension here, as the emphasis in policy on making technology responsible does not always line up with the work a social scientist actually does. Viseu was interested in studying how the social and the technical co-produce each other in nanotechnology's construction as a cultural practice, an aim she made clear from the beginning. However, in many instances inside the research centre, she was relegated to the role of "care-taker" which brought many emotional costs to her work. "Integrated social scientists are

asked to *care* for nanotechnology research and development by learning how to observe but not disturb. They are assumed to broaden the field, while simultaneously guarding its boundaries, shielding it from that which (and those who) stand outside 'proper' science." (2015: 2). In this way, Viseu argues that care becomes a government strategy in the quest to translate research into commercializable products, with social scientists being the main caregivers.

Power asymmetries were clearly marked between scientists and Viseu in the research centre, which allowed the scientists with more power to mask, ignore, or disallow the intended function of her research in their communications about the science that was happening there. This is a typical tension that has been described by several other social scientists working in interdisciplinary knowledge networks (see Balmer & Bulpin 2013, Balmer et al. 2013, Fitzgerald & Callard 2014, Fitzgerald et al. 2014, Rabinow & Bennet 2012).

For example, Viseu was repetitively introduced as the "ethics coordinator" to others in the research centre, and was chastised for giving undergraduate students texts to read that were not explicitly about ethical conduct in the lab. These regular miscommunications about her research meant that she could not effectively carry out the work that she was actually there to do. Time and again, she realized that her "integration" in the centre did not lead to increasing understanding of science and innovation and its wider interactions with society. Rather "integration meant managing a narrow listing of possible risks and consequences, such that if a scientist followed the instructions and ticked off all the boxes, she was 'social and ethical' and could go into the lab without having to worry again." (ibid: 12). In the eyes of the institute, Viseu was there to protect them from outside perturbations, which reified a values-oriented gender division in science, where women "do the ethics" and men do the technical work. The disciplinary divisions and power asymmetries that expected her to prevent perturbations in the nanotechnologists' research from the wider non-scientific world bore costs for her emotional and affective life in the workplace.

The aforementioned studies are approaches to analyzing how emotion and affect function in knowledge-creation networks and engagement settings, but they do not shed light on how emotion and affect shape the production of science communication. In the following chapters, I shift my focus to examine how the emotion and affect experienced by communicating experts (my research subjects) and the producer of the engagement event (me) are shaped by the material conditions of the engagement process, and how that in turn impacts the outcomes of engagement when making science communication. Therefore, I seek to contribute to an understanding of emotion and affect in science communication production, and what that calls upon engagement practitioners to do, which is currently lacking theoretical ground.

Chapter 2: Synthetic Biology

This chapter investigates the contemporary landscape of scholarship about synthetic biology-specific approaches to public engagement, and critical issues related to these efforts, in order to construct the basis for the methodology that guides this practice-based research, which will follow in the next chapter. However, in order to do this, I must explain what I mean by synthetic biology within the context of this thesis.

What is synthetic biology?

Synthetic biology has been accused of facing a "definitional quagmire" - a lack of any universally agreed upon description of its practices, aims, and products (Thomas 2014). To wit, a joke that I've heard retold by a handful of different people I've encountered in synthetic biology spaces (labs, conferences, etc.) over the time that I've been researching the field (since 2010) goes something like this: "In a room full of synthetic biologists, ask each one what synthetic biology is and you'll get as many different answers as there are people in the room."

Despite the multiple conceptions around what it might mean, the European Commission derived a working definition of synthetic biology from a survey study involving expert comment, which reads: "SynBio is the application of science, technology and engineering to facilitate and accelerate the design, manufacture and/or modification of genetic materials in living organisms." (2014: 5). Arguably, that definition is still a bit vague, and an equally vague common narrative has arisen in policy and media concerning synthetic biology, which describes the field as aiming to "make biology easy to engineer" (Jefferson et al., 2014). The narrative states that by making biology easy to engineer, scientists can control and exploit natural biological systems and engineer them so that they make valuable products, such as biofuels, drugs, food ingredients, flavours, or other valuable chemicals. Overarching all of these

descriptions is the fact that since the early days of its modern manifestation, synthetic biologists have wanted to "rid biological systems of their complexity in order to make the engineering of biology a set of routine and standard practices" (Endy 2005).

Synthetic biologists work predominantly (but not exclusively) with simple organisms such as yeast, bacteria and algae in order to engineer them to produce biological products as metabolic outputs that are helpful in the clinic, the biotechnology industry and in basic molecular research (Church et al. 2014). Although synthetic biology provides researchers with tools that they can use to do "fundamental research" (i.e. basic research about biology and how it works), the hope to create a sustainable, bio-based society with synthetic biology is a strong vision that results in more funding for the field's development than fundamental research does alone. Investment in the field's development has largely come from governments that use technological innovation as a form of nation building where "technical communities promising novelty and international competitiveness are rewarded by governments seeking an edge." (Balmer and Bulpin 2013: 5). Rob Meckin argues in his PhD thesis that this is particularly clear in a place like the UK, where the British government, out of fear of missing out on the "next big thing" - which they feel they did when the Americans spearheaded personal computing - named synthetic biology as one of the "8 Great Technologies" to benefit from serious British national investment (Meckin thesis). But the UK is not unique in supporting synthetic biology, and dedicated research centres that benefit from government funding have cropped up all over the world, including Denmark, Canada, the US, China, France, Germany, and other countries, and in many instances, researchers are encouraged by their institutions to form industrial partnerships (Jullesson et al. 2015). Examples of synthetic biology applications that have been developed industrially include drugs (the anti-malarial drug *Artimisinin*, made by Amyris with synthetic biology techniques that involve engineered yeast (Keasling 2009)), food flavors such as vanillin (researchers at the University of Copenhagen have been in a partnership with biotechnology company Evolva to

produce the synthetic flavor compound *vanillin* for several years (Møller et al. 2013)), and biofuels (Synthetic Genomics and ExxolMobil's alliance to create algae-based biofuels (Regalbuto 2009)).

Although much of the engineering work is done in bacteria, yeast, and algae, this diverse field is quickly moving towards engineering more complex organisms as well, for example in projects that touch on mammalian synthetic biology (Lienert et al. 2014). Furthermore, synthetic biology is increasingly spoken about in the same breath as other advancing areas of genetic modification, such as genome editing/genome engineering, which has gained much recent public attention as a result of CRISPR/Cas9 and other related technologies that have dramatically increased the degree of genetic engineering that is possible. For example: a conference called *Genome Engineering and Synthetic Biology: Tools and Technologies* sold out in 2016[4], and the PLOS (Public Library of Science) Synthetic Biology Collection has a sub-collection for its synthetic biology articles that deal explicitly with genome editing.[5] As humans increasingly design organisms at the full genome scale according to our own visions and desires, "such changes may entail a fundamental rethinking of the identity of the human self and its place in larger natural, social and political orders" (Pauwels 2011: 116).

A (very brief) history of synthetic biology

Historian of science Evelyn Fox-Keller has shown that synthetic biology was first coined as a scientific term in 1905 by French biologist Stéphane Leduc in his book *La Biologie Synthetique*, a work in which he sought to understand the chemical and physical mechanisms of life through their reconstruction in the lab using simple chemical systems that lacked DNA, such as metals and inks (2003). These substances, when combined under certain conditions, grew into complex structures capable of structural

[4] http://www.vibconferences.be/event/genome-engineering-and-synthetic-biology-tools-and-technologies, Accessed March 14, 2017.
[5] http://collections.plos.org/synbio-genome-editing Accessed March 14, 2017.

change that mimicked the growth of organisms. This property (now understood as osmotic pressure) at first seemed like the creation of a type of synthetic life, since its motility and growth patterns gave the impression that the systems were evolving on their own, rendering them life-like if not a curious version of life itself. Picture dark globs of chemicals that grew to look like a bed of fungi, or that spread outwards to look like a fish with fins. These "chemical gardens" were mimicking recognizable life forms in their structure, and at that early moment in the 20th century, it was hard to know that these features weren't more closely related to life than they seemed.

Today we are engaged in a very different type of synthetic biology, albeit one of contested originality or novelty. The term synthetic biology re-emerged in the early 2000s against the backdrop of more normative genetic engineering that has existed since the 1970s (recombinant DNA technology and later, metabolic engineering), which some scholars have called a "rebranding" of what was already here (Woolfson and Bromley 2011) and therefore nothing more than "old wine in new bottles" (Cole 2014). As a result, synthetic biology-derived organisms have been dubbed "GMOs 2.0.," particularly by watchdog groups that are critical of the field's potential impacts on the ecosystem and civil society (for example: Friends of the Earth, ETC Group, and Synbio Watch).[6] Some argue that the genetic engineering of the past, which synthetic biology is now characterized as being on the same continuum of, is only different in terms of the sophistication and degree of its ability to engineer genetic systems. However, others like the historian of science Sophia Roosth trace the dawn of synthetic biology back to a specific time around 2003 when a group of chemical, electrical and biological engineers at MIT decided that they wanted to turn biology into an engineering discipline that was as predictable and standardized as other engineering disciplines (Roosth 2017). They also claimed that the best way to understand how biology works is to build

[6] "GMOs 2.0 - Synthetic Biology." *Friends of the Earth.* Accessed March 15, 2017. http://www.foe.org/projects/food-and-technology/genetic-engineering/synthetic-biology.

it, and therefore used genetic design and manufacture as epistemological tools, not just as means to cause an engineered organism to make a desirable product. These engineers created the Biobricks Registry for Standardized Parts and the Internationally Genetically Engineered Machines Competition (iGEM) for students, which have been foundational to modern synthetic biology's communication and practice as a field for more than a decade (ibid).

Matters of concern

Bruno Latour has said "a matter of concern is what happens to a matter of fact when you add to it its whole scenography, much like you would do by shifting your attention from the stage to the whole machinery of a theatre." (2008: 39). Latour argues that this is the general action of "science studies" upon the sciences, which introduced a new gaze upon scientific fields that were once considered indisputable and "simply there" on their own.[7] Science studies turned the sciences into moving phenomena that are available for dispute once the observer zooms out to focus on how they are tethered to other social and technological apparatuses. Therefore, when it comes to matters of concern, everything looks different than how we were first told they did.

In synthetic biology, matters of concern are often talked about in two distinct ways that balance great hope with great fear. On the one hand, synthetic biology is said to one day be able to "heal us, heat us and feed us" (Osbourne 2012). This type of rhetoric is commonly used for explaining synthetic biology and is the main story that is put forth in introductory writings about the field (Marris 2014). On the

[7] This section and much of the writing that follows in the rest of this chapter appears also in my article Wray, Britt. 2015. Public Engagement in Synthetic Biology "Experts", "Diplomats" and the Creativity of "Idiots". *Ambivalences of Creating Life* Societal and Philosophical Dimensions of Synthetic Biology. Part of the Ethics of Science and Technology Assessment book series. Accessed September 18 2015. https://books.google.com/books/about/Ambivalences_of_Creating_Life.html?id=lFh1CgAAQBAJ.

other hand, upon further scrutiny, we are told that synthetic biology could also lead to a host of unintended social and environmental problems. Among those often listed are new forms of bioterrorism, biosafety issues, patenting concerns, inequality, as well as a growing cultural mindset that relies on "technofixes" instead of tackling root problems (Jefferson et al. 2014).

Related to this is the common narrative that says that today's synthetic biologists can "make biology easy to engineer." This supposes that they have enabled a "de-skilling" of the science, creating greater access to genetic engineering technologies for non-trained professionals, which in turn increases the field's susceptibility for misuse, abuse and "dual use" (Schmidt 2008; Kelle 2009).[8] "Dual use" technologies can be used for desired (responsible) and undesired (misused or abused) outcomes. Dual-use topics in synthetic biology range from biofuel and cheap drug production on the one hand (favourable), to novel bio-weaponry of mass destruction and microbes that could escape the lab to invade and destroy surrounding ecosystems on the other (undesirable).

Scholars have argued that the hopes and perils that get communicated along with the principle that synthetic biology aims to make biology easy to engineer bolster the speculative promises of the field. This can strengthen the circulation of myths about its potential dangers in a fashion that drowns out more accurate and nuanced discussion of the field (Marris and Rose 2012). For example, an interdisciplinary consortium gathered at Kings College in London to discuss the degrees to which threat, risk and safety concerns in public discourse on synthetic biology are valid, or conversely, blown out of proportion. They concluded that there is simply too much concern over hot air. Specifically, they reported that the common narrative found in numerous media stories about synthetic biology frames its advances as

[8] There are a variety of questions raised by synthetic biology that circulate in policy and media that extend far beyond its emergence as a "de-skilling" science. These include social justice for the global south, responsible innovation, ontological implications, modes of regulation and governance, its impact on the bio-economy, and more. In this chapter I am using the example of "de-skilling" and the related term of "dual-use" to make a general point about societal concerns, but do not mean to regard these concerns as the only topics that have garnered attention and debate.

"de-skilling" science, making it of greater access to non-trained professionals, and therefore susceptible to potential "dual use." But this idea asserts a strong element of technological determinism: the belief that science progresses in a linear forward-marching fashion, acquiring new successes and problems along the way in a predictive path (Jefferson et al. 2014). However, where there is little evidence to support such predictive and inescapable advancement in practice, specialists and publics are left to grapple with "speculative ethics" (Nordmann 2007).

Technological determinism therefore paints a picture whereby synthetic biology continues to advance and accrue successes in de-skilling biology towards an unstoppable future. However, the researchers discuss that this type of thinking fails to consider the myriad real scientific challenges that synthetic biologists face while trying to make biology easy to engineer in the lab (Jefferson et al. 2014). The implication is that this failure overlooks the importance of tacit knowledge, which only expert experience can cultivate over countless hours of intimate tethering with their research, study organisms, and lab methods. This therefore significantly limits the degree to which *just anyone* can do it well. Highly skilled professionals are still very much integral to the field's successes. However, this has generally been dropped from public-facing narratives that promote synthetic biology's revolutionary potential to open up access to wider communities of practitioners.

The potential implications of synthetic biology are myriad, and there are more individuals who want to weigh in on that discussion than just the scientists and engineers who are directly involved in the field's development. Over the last several years, synthetic biology has witnessed a wide range of scholars and practitioners take part in its research and wider societal debate. At a time when the (at least theoretical if not always practical) "de-skilling" of biological engineering is being brought to bear in synthetic biology, diverse individuals are claiming more participation and openness in communities and projects that contribute to and engage with the field.

Synthetic biology has been noticeably proactive in inviting interdisciplinary creative talent to contribute to its discourse and state of the art research (Calvert 2010; Marris 2014). This ethos can be traced in synthetic biology through the activities of a movement like DIYbio or biohacking, where individuals "tinker" and "make" using biotechnology outside of normative institutional settings (Penders 2011), the increasing participation of artists, designers, social scientists, ethicists, anthropologists and other non-synthetic biologists at events like the International Genetically Engineered Machines Competition (Agapakis 2014)[9], and the growth of bioart projects that critically explore synthetic biology (Kerbe and Schmidt 2013). Specific instances can be found in numerous experimental engagements that concern the field. These can range from events like the Kopenlab biohacking festival in Copenhagen[10], to bioart workshops in Genspace (a community lab in Brooklyn)[11], to international government-funded residency programs like Synthetic Aesthetics.[12]

In each their own way, these activities have entered the realm of synthetic biology as participatory sites, that often (but not always) enable individuals to engage with synthetic biology even if they lack expertise in it. In the case of DIYbio ("do-it-yourself" biology) and biohacking, professional scientists have often offered their expertise to DIYbiologists, and can sometimes be found actively participating in

[9] 2014 marked the first year that iGEM had a competitive track for teams whose projects explicitly mobilized art and design in synthetic biology. http://2014.igem.org/Tracks/Art_Design. Accessed 01 Sept 2014.
[10] The Kopenlab festival was comprised of "a collaborative space for citizen science, DIYbio, contemporary art and maker culture." It took place as part of Science in the City during the Euro Science Open Forum, Copenhagen, 2014. http://kopenlab.dk Accessed 14 June 2014.
[11] Genspace has been serving New York City as an outreach centre promoting citizen science since 2009. In 2010 it became the first-ever community biotechnology laboratory with a Biosafety Level One facility. http://genspace.org/ Accessed 05 Sept 2014.
[12] Synthetic Aesthetics was an international research project investigating the crossover between art, design, social science and synthetic biology. http://www.syntheticaesthetics.org Accessed 19 Nov 2014.

DIYbio spaces (Grushkin et al. 2013)[13]. However, they take a non-institutional approach to practicing science when they do so, and offer alternatives to traditional assumptions about how science should be carried out. Similarly, when artists and designers get involved in the field, they may inject their own creative modes of thinking and making into scientific spaces through the experiences, objects and collaborations they make, which in turn may expose synthetic biologists as well as publics to new ways of looking at, and questioning, the field (Schyfter and Calvert 2015).

But why is it that synthetic biology, as a professional discipline, has been so tolerant of so many different types of practitioners and theorists, who are often not experts about the scientific dimensions of synthetic biologists' work, weighing in on the field's development? There may be several reasons for this, but a good place to start would be to look at what it is about synthetic biology that funders think is worthy of scrutiny from diverse groups, and by extension society at large. What do funders expect society might become concerned about as synthetic biology becomes more of a household name? And how might funding multidisciplinary explorations of potential issues create a sense that these concerns are being dealt with responsibly, and early on, in the eyes of publics? It is also important to consider what kinds of status the field and its practitioners are afforded when they appear to be engaging with its matters of concern, opening itself up to painful scrutiny from diverse multidisciplinary players. What kind of trustworthiness does that demonstrate? And is it an attempt to engineer the publics' trust? I will return to these points.

So, what are some of the obvious matters of concern that funders might have about the way

[13] Biohacking, which includes the DIYbio community, is a heterogeneous "scene" that does not adhere to any one movement, mission or aim. At the 2015 PACITA Technology Assessment Conference in Berlin, German biohacker Rüdiger Trojok gave an elucidating talk about the complexities of the biohacker identity. He explained that although biohackers around the world seem to celebrate the non-institutional practice of biotechnology, they are far from a unified community. For example, some groups in North America (more closely aligned with DIYbio) affiliate their work with the possibility for commercialization, while others in Europe and Asia align more closely to an anti-capitalist and activist ethic.

publics perceive synthetic biology? The field has been often associated with pre-existing debates about genetically modified organisms (which were particularly heated in the 1990s in Europe), as well as public disapproval and concern that comes to mind when one hears the word "Monsanto" (Kronberger et al. 2011). When funders and advocates of synthetic biology actively strategize to avoid such comparisons in the public discussion of synthetic biology, this creates what Claire Marris has called "synbiophobia-phobia," or the fear of a synthetic biology-fearing public. In this case, synthetic biology's supporters see "public attitudes" as a major obstacle to what synthetic biology can contribute to the "public good" (2014). Therefore, they strive to distance synthetic biology from these earlier controversies in the way it is talked about and represented, and by doing so they make quick assumptions about what publics will approve or disapprove of concerning the field's activities. This connects to what Sarah Davies has argued, (described in chapter one) that science engagement often – misguidedly – aims to make publics "love" science from their first point of contact. But what types of engagement experiences might be possible in the vast gulf that exists between love and fear of science, that synthetic biology phobia-phobic approaches to engagement risk missing out on altogether?

In order for synthetic biology phobia-phobia to function, publics are imagined to react in certain ways before they even show up to a scientific engagement experience and make their voices heard. Marris argues that imaginary conceptions of "the public" and their perceptions of synthetic biology often get inserted into public discussions about synthetic biology in the place of the publics' actual convicted views: "They are omnipresent as disembodied, imagined, publics but absent as actual persons or organisations" (2014: 90). Marris gives accounts of leadership councils and national research forums on synthetic biology which have excluded real lay publics from attending, and shows that when a place is made for publics, the very identity of who "the public" is can sometimes be misplaced. For example, while she was once embedded as a social scientist in a synthetic biology research network, Marris and her social

scientist colleagues were labeled as "members of the public" when they were collaborating with synthetic biologists in engagement events. This was a gross misjudgment, as their role in that network was to assess the ethical, legal, and social implications of synthetic biology with social scientific expertise, which is altogether very different from standing in as representatives for generally interested citizens. Producers of public engagement events, like myself, have a responsibility to reflect on whose voices are being included sincerely when we invite people to engage, and to consider what it is that they are really being asked to do in their role as a participant. An important element of this, which I take up and develop further in this thesis is the idea that engagement "event producers can look at how their participants accept and take up or resist and transform the roles they were offered as participants during the engagement process as it unfolds. This has been written about before as "machineries for making publics" (Felt and Fochler 2011). However, where Felt and Fochler's work concentrates on how members of the public accept or resist and transform their roles as participants in engagement events, I focus here instead on how communicating experts, such as social scientists who are embedded in synthetic biology networks, accept or resist and transform their roles as participants in the process of making science communication happen, before any engagement with publics takes place. Among other things, I argue that engagement event producers should take notice of these considerations and adapt their engagement projects with them in mind in order to resist synbiophobia-phobic approaches to engagement. The hope is that by doing so we might be able to foster space for more sincere engagement to occur.

Whatever form the engagement event may take, in synthetic biology, there are many diverse creative sites for engagement that enable imaginaries of what the field means to bubble over into public consciousness through their representation at science festivals and genetic engineering competitions, on blogs, in galleries, on the airwaves, in social media and more. In effect, it is not only professional science communicators that identify as such, or synthetic biologists, that are crafting and telling stories to publics

about synthetic biology. These experimental entanglements have created a metaphorical agora for discussing issues in synthetic biology from multiple points of view. In ancient Greece, the agora was the city's public meeting place: the heart of artistic, political, spiritual and athletic life. As one can imagine, it was where topics that carried significance for debate were openly discussed among different publics. As Eleanor Pauwels points out, in synthetic biology, "matters of concern create an 'agora'; they create political conditions for dissenting imagination" (2010: 1447). Today, synthetic biology matters to heterogeneous groups in heterogeneous ways, creating a modern agora at their sites of intersection that are worth engaging with (Pauwels 2010).

Interdisciplinary collaborations and matters of concern

Within spaces of academic expertise, several strategic interdisciplinary working teams have been formed to develop and assess synthetic biology practices "upstream" from their widespread deployment in culture and science at large. These working groups often comprise ethicists, philosophers, anthropologists, sociologists, and STS scholars that work in collaboration with scientists to address problems that may arise as the technology develops, or ensure that the field's development complies with a responsible research and innovation (RRI) framework (Owen et al. 2012). Amongst other things, they also work to establish deeper understandings of what is actually happening in the present state of the field, and how scientific research functions as a cultural practice.

Rabinow and Bennet have said that these interdisciplinary models of synthetic biology and society interaction require significant refashioning when compared to similar initiatives that have previously occurred in the biosciences (2012). They argue that earlier iterations – as seen in The Human Genome Project for example, the largest ELSI (ethical, legal, and social implications research) project to date – are not satisfactory models to follow for interdisciplinary collaboration in synthetic biology. According to

them, synthetic biology marks a new "post-genomic era" where nature is being re-invented rather than merely studied, and we must therefore acquire new tools to deal with it responsibly (2012: 267). Importantly it is also, they argue, because ELSI research frameworks have often had the effect of bringing critical interdisciplinary thinking into a field *after* the science and innovation has happened. In other words, it tends to get incorporated as an analytical afterthought that gets "tacked on" and can be "checked off" once the humanities and social science scholars have examined the science and engineering that's already in motion.

Such a "downstream" approach has been criticized for missing the rich opportunities that are created when diverse perspectives are brought together to consider technological futures before they materialize, and must then be responded to (Balmer and Bulpin 2013). As a result, the shift to a "post-ELSI" framework that is operationalized by "upstream" interdisciplinary collaborations between synthetic biologists, social scientists, ethicists, etc. have become more common, which bring thinkers with different expertise together at early stages in a research process (similar to what I discussed in chapter one in a nanotechnology context with Ana Viseu's research). However, some scholars have questioned the validity of a post-ELSI shift (Myskja et al. 2014). The post-ELSI shift is connected to the fact that "social scientists are becoming a required component of synthetic biology research programmes in Europe, the US and beyond" (Calvert 2013: 176). These days, grants may not be awarded to synthetic biology researchers without the presence of social researchers on their team. Their involvement on paper is perceived as accounting for "cheques and balances" of the research in a responsible manner, especially when post-ELSI researchers arrive earlier rather than later in a synthetic biology project's development.

In theory, collaborations between social and natural scientists often seek to identify important questions that should be asked about synthetic biology's practices and implications before any unintended effects develop. Despite these aims, some social scientists have reported that they suffer from

having limited power in their relationships with synthetic biologists. Rabinow and Bennet gave a concerned account of their experiences as anthropologists employed at Synberc – a large American multi-university synthetic biology research centre – where they felt that their humanistic perspectives were met with dismissal, disinterest, and at times, hostility, from their scientific collaborators (2012). Jane Calvert, a social scientist who often works with synthetic biologists has said that she has at times felt that what she has to offer has been snubbed by the scientific community. As a result of her experiences, she advises non-scientists attached to the field to embrace an "ethics of discomfort" (Calvert 2013: 189). Furthermore, a manifesto was written by a group of social scientists actively working in European synthetic biology centres, calling for new experimental forms of collaboration with scientists so that more fruitful outcomes might be discovered for all parties involved (Balmer et al. 2012). Many of the same researchers published an article called *Five Rules of Thumb for Post-ELSI Interdisciplinary Collaborations* in which they identify the need for collaborative experimentation, taking risks, collaborative reflexivity, opening-up discussions of unshared goals and neighbourliness as tactics to make the most of what can otherwise be quite difficult research experiences (Balmer et al. 2016). However, as a colleague of mine once mentioned, the pseudo re-invention of "experimental collaboration" with good etiquette may be nothing more than the end of independent funding for critical scholars.[14] This line of thinking is also echoed by scholars who question the validity of a post-ELSI shift (Myskja et al. 2014).

Conflict in post-ELSI collaborations is of interest to me here because it renders visible what opportunity there is for experimenting with new forms of communication between people who work on synthetic biology, which I will further develop in the practice-based research-creation output of this thesis.

[14] I thank Dr. Kristin Hagen for this comment.

Experts, diplomats and idiots

The philosopher of science Isabelle Stengers has prompted scientific experts to think about how they might put forth proposals in their fields that do not claim "what ought to be" but instead cause a "slowing down" of common reasoning to allow for deep reflection. The aim of this is to create opportunities for alternative ways of being and acting around matters of concern that are relevant for their work (Stengers 2005). For Stengers, slowing down thinking in this way is about finding room to become slightly more aware of the problems and situations that mobilize a group of experts to work on a problem in the first place. She is explicit in saying that her ideas are intended for practicing experts, rather than generalists. They are therefore of relevance to my discussion here about interdisciplinary collaborations that involve multiple expert points of view that hail from various disciplines involved in synthetic biology networks.

Although Stengers focuses her thinking on expert communities, for the purpose of her analysis she also discusses two other important figures and how they function in causing expert reflection: the "diplomat" and the "idiot" (Stengers 2013). For Stengers, experts are the ones whose practices are not threatened by the debates that concern them, because they are expected to present what they know and are not expected to foresee the ways that their knowledge might be taken up differently by others in varying situations. Synthetic biologists would the most obvious examples of experts in their field that operate according to this identification.

Contrastingly, diplomats are those whose identities are threatened by their practices. They serve to destabilize any homogenous acceptance about how science can advance "the general interest." Instead, diplomats provoke experts to think about the unexpected, dark, or skimmed-over possibilities of their practices, the very existence of which make them experts. They call expert assumptions into question and show how things could have always been otherwise. As a result of the aforementioned post-ELSI

collaborations, I suggest that it is post-ELSI researchers who take up active diplomatic roles in synthetic biology networks that we can look to in order to understand how diplomats work in this field. These roles are inhabited by a wide variety of social researchers, such as social scientists, ethicists and STS scholars, but also by extension, artists, designers, and biohackers that intervene in synthetic biology spaces and discourses. They engage publics about the science in process, as well as interfere with experts by shadowing them in their labs during ethnographic studies for example, or by collaborating with them on interdisciplinary art projects that brings "outsider" or *diplomatic* knowledge together with that of the synthetic biology expert. They also interfere with scientific thinking by posing critical questions to expert practitioners about their approaches to their research, as can be seen in the aims of post-ELSI research. The conflicts found in uncomfortable interdisciplinary research collaborations are evidence of how diplomats are able to interrupt and even threaten expert programs in synthetic biology.

Furthermore, Stengers mobilizes the ancient Greek character of "the idiot" in her analysis. The original term "idiot" was meant to describe someone who did not speak in ancient Greece and was therefore cut off from community relations. However, through a reading of Deleuze's philosophical remediation of the figure, Stengers revitalizes the idiot figure to mean one who resists the way that an expert situation is presented. The idiot does not feel the urge to fall into consensus with any particular narrative, and importantly, by not doing so, he or she galvanizes others around them to call the narratives that surround them into question as well. The idiot therefore does not interact with science as such, but with the politics and economies of it. The idiot is a catalyst of political thought and action through their refutations of all narratives, moving others to ask: "what is more important that we should be doing?" But the idiot is not righteous and does not know the answer. For Stengers, the idiot is key, not because he or she creates unending perplexity for a situation at hand, but because the idiot makes us slow down and question our own assumptions. The idiot's actions make us look for whatever made us feel we were

authorized "to believe we possess the meaning of what we know" in the first place (2005: 995).

Therefore, diplomats and idiots are not the same, but they both "jam the system" of expert knowledge. This makes it more difficult for expert knowledge to blindly promote the science and technology being discussed; make assumptions about how publics will perceive it (synbiophobia-phobia); or perpetuate "performative statements" about their field. "Performative statements" are declarations that step in at any point from an expert point of view, to not only describe the world, but actually *do* something in it. For example, performative statements that declare synthetic biology is "making biology easy to engineer" do not simply state an empty slogan, but serve to unify its nearly irreconcilably diverse practitioners in real life under the banner of this singular and often-repeated vision (Bensaude-Vincent 2013).

Experts, diplomats and idiots in action

An art project can illustrate how the expert, diplomat and idiot work may together in a project that engages publics to think about synthetic biology. In 2013, artists Oron Catts, Ionat Zurr and Corrie Van Sice exhibited a work called "The Mechanism of Life – After Stephane Léduc" at the Science Gallery in Dublin as part of the "Grow Your Own" exhibition. The artwork reflected on the origin story of how people have come to use the term synthetic biology. As I mentioned earlier, the person believed to first use this term was a French scientist named Stephane Léduc who thought that he had found evidence in the lab that life was merely a chemical mixture, devoid of any metaphysical forces (Keller 2003). Léduc created organic-looking life-like entities in the laboratory by mixing metals, oils and inks, which were used to speculate about the engineerability of life from scratch. For Léduc, these life-like blobs showed that living things could be created according to a chemical recipe, giving rise to what he called *La Biologie Synthétique* (1912).

Catts, Zurr and Van Sice's piece comments on the type of synthetic biology we have today, which although paradigmatically different from Léduc's early version of it, is still underpinned by a belief that life can be reduced to its interlocking chemical parts, and consequently, engineered. This "engineering mindset," they argue, is what synthetic biologists use to design and build living systems as though they are guided by simple mechanistic processes that do not amount to something greater than the sum of their parts. To demonstrate this critique, the artists re-created Léduc's early chemical experiments in the gallery using a rapid prototyping machine, or 3D printer. Rapid prototyping is highly anticipated to revolutionize the sustainable fabrication of goods through distributed manufacturing in this century. Similarly, synthetic biology has been the subject of the same type of narrative in its marketing to publics, where it is said that we will one day be able to make everything from medicines to perfumes at home with desktop DNA synthesizers.

In the artwork, the rapid prototyping machine mixed chemicals that Léduc had worked with more than a century earlier. But where Léduc claimed that their interlocking reactions constituted synthetic life, the artists exposed them to public visitors in a gallery as nothing more than what they are: droplets of mixed chemicals. By doing this experiment in an art setting, the visitors could see that these droplets - of an "engineered life force" - only lasted a few seconds before dissipating into an entropic, murky, chemical soup. If Léduc had seen the same murky chemical soup appear after his synthetic form of "life" had "died," his memory of it did not make it into how we talk about his anti-vitalism experiments today. Therefore, this artwork opens up rather than closes down questions about synthetic biology by bringing the past and present into the same art-object for audiences to consider. The artists managed to unify the past and present in one conceptual apparatus, which is particularly difficult to do, as Bensaude-Vincent has argued, because "futuristic visions are so attractive that they blind the past" (2013: 28).

Using Stengers to analyse the artwork, on the one hand, the artists here become *diplomats*

whose efforts question the rhetoric of the *expert* (Léduc - a historical scientist) by creating a space to reflect and ask critical questions of the expert's claims. On the other hand, the unstable droplets become the *idiots* that force viewers to question the situation that is in front of them, without telling them what to think. The work comments on the tension of what experts say they know: that life can be engineered through mechanistic reactions; what diplomats reveal: the blind spots and biases of expert knowledge; and what the idiots force us to re-evaluate by breaking the whole system down. "The Mechanism of Life – After Stéphane Leduc" is therefore one example that demonstrates how engagements with publics can be critical and emergent through "diplomatic" and "idiotic" behaviour.

I do not mean to imply though that from following a legacy of bioart into the present and bringing non-traditional players into scientific spaces, that critical discourse is automatically generated for richer and more reflective public engagement with synthetic biology. Interdisciplinary experimentation does not inherently allow for better descriptions of the world than what is provided by experts alone in synthetic biology. It is not enough to say that bringing artists into the lab brings critique into the lab; they're not the same thing. Similarly, making hacker spaces for DIYbio does not necessarily achieve the dream of a democratic biotechnological era. In some cases it might not do much more than fetishize the transformation of biotechnologies into personal technologies for new commercial markets, similar to what occurred with personal computing (Tochetti 2012).

To push this point further, in some cases, the inclusion of artists and designers (as well as social scientists) in synthetic biology has been criticized as "instrumentally motivated engagement" that has been "co-opted for legitimization and science communication" by the scientific community, their funding bodies and policy institutions (Hagen 2016: 201). Hagen argues that this is a result of science policy that expects public controversy around synthetic biology to prevent innovation (another form of synbiophobia-phobia). Therefore, in order to make the field appear less controversial and more appealing, artists,

designers and post-ELSI researchers are actively included and recruited as "tribes" in synthetic biology networks and projects, which makes the scientific community appear responsible and responsive to societal concerns. However, these activities are often funded by the same bodies that fund scientific innovation in the field, which Hagen points out means that genuine critical intervention may not flow forth from the inclusion of these "tribes" in the field. "No matter how ethically sensitive, responsible, open and engaged a scientific community wants to be, it may arguably be too much to expect activities that deeply question the field, decrease its funding opportunities or increase the risk of public contestation." (2016: 206).

But the invited "tribes" are not restricted to artists, designers and post-ELSI researchers; they may include public engagement practitioners, like myself, as well. Morgan Meyer wrote about a public debate that took place in France in 2013 in an article entitled *"Participating means accepting": debating and contesting synthetic biology*. It explains how this particular debate's organizers were critiqued as working to promote the acceptability of synthetic biology while deceiving themselves that they were creating a platform for genuinely open-ended, critical discussion that could make a difference to the way synthetic biology is carried out. The particular event he writes about was framed as a forum where a biotechnologist, a philosopher, and a geneticist would debate the question "does synthetic biology exist?" (Meyer 2013). A few minutes into the debate, 15 protesters in chimpanzee masks from the group PMO (Pie`ces et main d'œuvre) barged into the room to interfere with the discussion. They had various tactics to interrupt the speakers, which they managed to do for 1.5 out of the scheduled 2-hour event. They carried posters that read "participating means accepting," put stickers on the walls that said "hollow debate worse than for the nanos" and chanted the slogans "false debate, we do not participate" and "we will be there, at each false debate" (ibid: 127). They distributed and read from pamphlets that said,

> "In this pseudo "Forum of synthetic biology" you can say whatever you want. It does not matter, it has no impact. It will not change the development of synthetic biology. The decisions are made, the programs been launched. While you are distracted by this spectacle, Total, Sanofi, Monsanto, INRA, CEA, Genopole manufacture synthetic bacteria and artificial genetic code…For these manipulators of opinion, it is necessary that we participate to this masquerade. As they say: "To make people participate is to make people accept". If we participate in this parody we let believe that a democratic debate took place…Participating means accepting." (Pamphlet of 25 April 2013, signed the "Chimpanzees of the future")

Meyer analysed the function of the protesters' claims, and calls them "indivisible" criticisms because they are total, radical, and impenetrable. There can be no discussion with the protesters in terms of thinking about how to work within the framework of synthetic biology considering their outright rejection of the technology. But even though their indivisibility leaves little room for engagement, the chimpanzees of the future's disruption forced the producers of that debate forum to reevaluate their understanding of terms they normally take for granted, such as "debate" and "participation". Their critique forced the organizers and participants in the room to be brutally reflective about what they were really engaged in doing. The chimpanzees therefore acted as "diplomats" in the way Stengers meant, questioning what the experts know, creating space for critical contemplation of the process they were a part of. Public engagement practitioners are not criticized as often in the literature as artists and ELSI researchers are in terms of how our work may be co-opted to promote "synbiophobia-phobic" agendas, but we should reflexively question what effect our work really has on the field just as much as them. "As we see, the organization of debates on science requires continuous work – both at the organizational level and at the conceptual level." (Meyer 2017: 130).

Synthetic Aesthetics

Similarly, Synthetic Aesthetics is an art and design case study that has been accused of

window-dressing synthetic biology for public acceptance. Synthetic Aesthetics is one of the most visible and ambitious communication and collaboration projects to date in the field of synthetic biology. It brought artists, designers and social researchers into the labs of synthetic biologists (and vice versa) in order to work towards open-ended, inquiry driven creative projects with the hope of stimulating critical discussions about the field and generating new interdisciplinary knowledge. It was a research and creation residency program funded by the US National Science Foundation and UK Engineering and Physical Sciences Research Council that brought synthetic biologists together with artists, designers, a social scientist and a philosopher to produce works that question how people might like the technology to be used (Schyfter and Calvert 2015).

Since synthetic biologists and designers share an interest in creating new solutions for identifiable problems, it has been argued that as biology becomes a product of design choices over evolutionary pressures, collaborations between synthetic biologists and designers may be able to shed light on the question of "how to design life well?" (Ginsberg et al. 2014). The Synthetic Aesthetics residents considered this question at a time when international efforts were (and still are) being made to find solutions for new sustainable manufacturing techniques, carbon neutral fuels, cheap drugs and rare high-value materials with synthetic biology. Through six paired teams consisting of one synthetic biologist and one artist or designer each (including Oron Catts - mentioned earlier), their collaborations sought to explore and/or question how and why we might now work to manufacture possible futures through biological design.

The Synthetic Aesthetics residency launched in 2010, and engaged the artist, designer and scientist residents to produce interdisciplinary works that came about partly in the artist or designer's studio and partly in the scientist's lab over several months. The teams were studied by a philosopher and social scientist, and the entire project was overseen by design and science fellows who helped facilitate the

initiative. To conclude the residency experiment, the organizers published a book by the same name that uses the project as a frame to explore the role of *design* in a world where scientists are "designing nature." The book fostered discussions and writings from the social sciences, humanities, science, engineering and design researchers attached to the project (Ginsberg et al. 2014). The residents also made several public appearances throughout the duration of the residency program, sharing their projects and processes of collaboration with audiences at galleries, festivals, conferences, and broadcast interviews. The creative outcomes of the project ranged from speculative packaging that grows itself, to cheeses produced with bacterial strains found on the human body (although the bacteria didn't even require genetic engineering for their creation), to philosophical reflections on the cultural motivations for the field. Though not an exhaustive list, such diverse outcomes demonstrate how varied their approaches to interrogating synthetic biology with interdisciplinary experimentation were. Each team made artifacts or conceptual works that traveled to different exhibition spaces and engaged publics with varying degrees of provocation, humour, and critique.

In some cases, the creations that were made during Synthetic Aesthetics are considered part of a larger movement known as speculative design. Speculative design uses design as a conceptual tool in the vein of art to produce objects and experiences that explore possible futures by presenting some instantiation of them to audiences (Dunne and Raby 2013). Speculative designs work at the nexus of where the technological and the social intertwine, prodding people to reflect on what they think the technologies suggest for their own lives, through narratives that the designs themselves propose (ibid).

One well-known example of speculative design in synthetic biology, which opens up the question of "how to design life well?" comes from designers Alexandra Daisy Ginsberg (who was Design Fellow on the Synthetic Aesthetics project) and James King. The designers created a probiotic yogurt drink containing synthetic microbes that can detect and report health problems in the gut by speckling one's

faeces with a specific colour that correlates to a particular disease or infection that the bacteria sensed. The yogurt drinkers are therefore told that they need to visit the doctor before more unfortunate symptoms appear when they see the colour of their excrement. The project - *E. chromi* - was developed with the 2009 International Genetically Engineered Machines (iGEM) competition-winning team from Cambridge University and is based on real research in synthetic biology that shows synthetic bacteria are able to produce the pigments they exhibit in their "Scatalog."[15] However, the yogurt drink does not (yet) exist as a real product on the market. The Scatalog has travelled with the designers to several exhibitions, conferences and festivals where it serves as a catalyst for conversation with publics. Peering at the multi-coloured excrement in the sleekly designed case, people who encounter the Scatalog in places where it travels are encouraged to think about whether or not they think the yogurt drink containing genetically engineered bacteria would be a good application of the technology at wide societal scale. This provocation then opens up a portal for further discussion about the implications of synthetic biology itself. It is basically "poo as public engagement probe."

But some have critiqued speculative design about synthetic biology as being not much more than disguised advertisements for the field that sell synthetic futures to audiences in the present. The well-crafted, beautiful and seductive objects and exhibits they create show how an engineered biological future may function not only on the genetic, but societal scale, allowing publics to imagine how they might like to use it. It is because they tell stories about how emerging technologies might affect our lives that speculative designs have been subject to a considerable amount of casual debate at synthetic biology conferences, festivals and workshops I've attended. Despite these off-record debates, many speculative designers, such as those involved in Synthetic Aesthetics, have argued that their work opens up speculative futures that invite emergent interpretations to be formed in the minds of their audiences, rather than prescribed

[15] http://www.echromi.com/. Accessed 04 March 2015.

judgments about how the technology should be supported.

If we are to take that argument to heart, speculative design has more in common with scientific media about synthetic biology (for example, as produced by the press) than may be obvious at first glance. As Todd Kuikens and Eleanor Pauwels argue, "the press (concerning synthetic biology) may not tell the public what to think, but by covering topics it often tells them what to think about" (Kuiken & Pauwels 2012: 2). Similarly, speculative design becomes another platform for "thinking about" the field. However, whether it works to market synthetic biology (by supporting expert narratives) or critique it (diplomatically or idiotically) cannot be understood at face value and must be considered on a case-by-case basis.

Materiality and affect in public engagement about synthetic biology

Something that all of the aforementioned art and speculative design projects use in their engagement work is materiality: non-discursive elements of communication that conjure meaning in the audience's minds. Common examples are the metals or plastics objects are made of, what colours they hold, what smells they carry, what they feel like to the touch. Returning to Sarah Davies' line of thought, we should be paying attention to "the non-discursive – to the role of, for instance, the emotional, material or creative within public engagement" (2014: 94). Davies argues that when science communication focuses too much on the content and discursive elements of public engagement work it misses an opportunity to dive into the affective ability of the non-rational and chaotic elements of that content to make people literally *feel some way* about science. Science dialogue events for example can be "dramatic and emotional" when people come face to face in public to discuss a scientific topic (ibid). However, science communication researchers may boil down the effectiveness of engagement events to a series of evaluation criteria that overlook any of its sensory elements. Science communication and engagement projects ranging

from lectures to workshops, gallery exhibits, films, radio broadcasts, interactive installations and more have inherent sensory dimensions that prop up our experience of them. Admittedly, some of these formats enable more participation with publics than others, but even those that communicate more uni-directionally than not have non-discursive elements to them. The colours on a screen, the tone of voice being used, the speed at which one travels through an exhibit, and all other embodied aspects of engagement work are perceived on levels that often remain invisible to scholarship. But as you may recognize from personal experiences, these types of material elements can significantly affect how you come to think about, feel, and participate (or not) in engagement settings. In this way, these material elements can function similarly to how the positivity or negativity of emotions affects how much people may engage in participatory settings, which Harvey's work demonstrates (2009). This also resembles how the positivity or negativity of emotions in educational settings shape how relatively frequently or infrequently students will participate (Appleton et al. 2008).

Furthermore, the way in which creative public engagement about synthetic biology is materially presented has the possibility to influence how audiences think about the field. For example, at a bioart exhibition in Vienna called Synth Ethic that featured artworks dealing with synthetic biology, researchers found that the majority of visitors to the exhibition sensed no ethical problem with the use of bacteria and other "lower" organisms in any works of living art. However, when animals of higher biological complexity or humans were posed as part of the artwork, real ethical discomfort ensued. The gallery visitors expressed a general need for boundaries to be implemented around how far certain biotechnologies and their practical attachments should be allowed to be developed, along the lines of organismal complexity (Kerbe and Schmidt 2013).

The valences of representation in the works at the exhibition differed (and were perceived differently) most obviously in terms of the complexity of the living organisms involved. Therefore, the

organisms used had the power to sway public opinion in terms of the degree of "wrongness" of the artwork, reverberating into opinions about the overarching visions and practices of synthetic biology itself. In this sense, the artist's choice of organism became material to how people think about the technology that the artwork explored. And so, it became a material choice with real implications that the artist was responsible for. Therefore, the material choices of the artist – and I would argue of the designer of any engagement experience - are tools that can, in part, influence how people's engagement experiences do or do not travel with them as they inhabit the world in different ways, and apply those experiences as knowledge to make sense of the world with.

Practitioners of public engagement and science communication should not forget the importance of how materials, sites, temporalities, and emotions inform and shape the roles that publics and experts inhabit when engaging with a topic like synthetic biology. Although artists and designers may possess special knowledge from their educational backgrounds about the affects such elements produce (aesthetically, phenomenologically, emotionally, or otherwise), other creative communicators of science (for example, writers, documentary makers, journalists, public speakers) might do well to explore their potentials as well.

While I am arguing for a shift towards the non-discursive material, affective and emotional aspects of science communication, I do not want to erase the importance of discursive aspects of science communication while doing so. Indeed, discursive storytelling about science can be the origin point for emotions and affects that are created in an engagement setting. Meckin and Balmer engaged publics to consider the uses of synthetic biology-derived menthol in their *Stirring the Senses* project, which asked publics to consider the various everyday uses of menthol in their lives (2017). They elicited stories from their participants about how menthol affects the human body, how it tastes and smells, how it can be used for pleasure, used to care for pain, and more. Their objective was to design an engagement format that did

not look for broad consensus or try to ascertain if there would be a "public rejection" of synthetic biology, suggesting normative institutional concerns about innovation and public acceptance. Instead they wanted to "encourage scientists and science communicators not to 'disconnect and de-problematise' innovations but to consider ways in which innovations are inherently connected to various public values." (2017: 1015). They collected a rich assortment of personal narratives about menthol, what it means to each person and how their understanding of it connects to public values in order to inform the debate on how we may or may not want synthetic biology-derived menthol to change the world. By meeting their participants in their homes, workplaces and everyday situations, their role as public engagement practitioners was to create a conceptual and physical space where the technology was not isolated or separate from its societal uptake, but its meaning was completely enmeshed and entangled within the fabric of normal daily life.

This turn to personal narratives that describe values is a valuable contribution for thinking about how public engagement practitioners can reveal important sociotechnical entwinements with their work. This makes a material difference to the kind of debates we can have about technologies, for if they're treated as controlled and isolated instruments, we will not be able to discuss how they operate at the level of individual and collective lives. The entwinement of personal storytelling with technological assessment is a "diplomatic" way, in a Stengerian sense, of opening up multiple narratives that can question what "experts" assume they know about a technology and its various implications.

So, how might public engagement practitioners incorporate the roles of experts, diplomats and idiots into the design of engagement experiences in order to allow emergent engagement to take place? I'm not suggesting that this type of question will serve all science engagement practitioners well, or in any particular way. I am suggesting that this question leads us in one potential direction, among many that exist, which could be helpful to explore in order to build space for non-prescriptive reflections about science into engagement experiences. Scholars have shown that public engagement projects about synthetic

biology should begin with narrative frames that deliberately position themselves away from assuming what publics might be thinking (Marris 2014). They can also benefit from treating publics as a diverse collective with various personal stories to share about how synthetic biology affects their lives and connects to their personal values, which cannot be reduced to a broad consensus about what the technology means (Meckin and Balmer 2017). Similarly, the frames should distance the engagement experience from trying to make publics feel affectionate for science, in order to create space for genuine emergent feelings to flow forth from engagement experiences (Davies 2014; Horst and Michael 2011). In this sense, I am arguing for more creative experimentation with how communication formats can deepen and slow down the ways we tell and share stories about synthetic biology, which I put into practice in this thesis. At the same time, I am also arguing for producers of engagement events to pay attention to the function of emotions and affects in their engagement events, which they can tune into by noticing how participants accept and take up, resist or transform the roles of participation that are offered to them by a particular engagement event's design.

Making room for emergence in public engagement with experts, diplomats and idiots

Scientists and publics are accustomed to being invited to interact with each other in formalized engagement events (for example: at a museum lecture with time for Q and A). But what room is there to allow individuals' feelings from both sides of the expert/audience divide to become part of shaping emergent engagement experiences that don't just follow expected structures? In this thesis, I ask how experimental approaches to public engagement with synthetic biology might redirect stale narratives (such as "dual use" discourse and "synbiophobia-phobic" communications) towards more emergent and unpredictable conversations (Marris 2014; Marris et al. 2014).

How can a move to noticing emotion, affect, and materiality foster space for more open

reflection and communication between experts and publics? Although such a move will always be subject to failure, could public engagement projects be helped by lessons that are being learned in interdisciplinary research networks that include "integrated" social researchers, about what it means to collaborate and communicate *well* across the disciplines? This line of questioning is in no way meant to lead to a path that can "smooth things over" or homogenize discussion into some form of agreement between various publics and experts on matters of concern in synthetic biology. It is meant to inspire new thinking about how we want to be discussing – and engaging with - our biotechnological futures in the "post-genomic era" through experimental forms of communication that listen more than they assume, and open up more than they close down.

This inquiry takes 'post-ELSI' research seriously, which declares that we need new "experiments entanglements" in knowledge production between scientists, social researchers and their publics that are "pluralist, reflexive, and promote mutual learning" (Balmer et al. 2012; Fitzgerald 2014; Rabinow and Bennet 2012). Perhaps by focusing on how people *feel* - as they're *doing* engagement – practitioners can achieve some of what Stengers' was arguing for when she declared we need to slow down and genuinely reflect more on what it is we think we know about technoscientific fields.

Returning now to Jefferson et al.'s argument that much of the public discourse of synthetic biology is based on technological determinism, something is needed to "jam the system" in how we think and talk about synthetic biology *in public* and *with publics*. Where is the diplomat who can ask those who make deterministic statements about synthetic biology how they came to believe what they know? Diplomats (who question the assumptions and beliefs in synthetic biology) and idiots (who 'misbehave' and disregard the way an engagement event is designed to function (see Michael 2012)) can help us question what we think we know, and discover that there are alternatives ways of learning from the engagement that are available to us. In other words, they allow us to critically reflect on what is happening

rather than stay gripped to an expert script of communication. These values – of questioning, reflecting, and opening up new modes of thinking – are held strongly by the emergent model of public engagement.

The question then is, how can engagement practitioners such as myself create fora for experts and publics to reflect, think and speak in open-ended ways that resist reifying predictable expert statements about science? What can be done to promote "diplomatic" and "idiotic" behavior in a landscape of science engagement that still often defers to the deficit model of science communication? It's fine and well to have esoteric theoretical concepts as inspiration for how one might design a public engagement event, but figuring out how to employ these theories in practice is important to try and resolve.

Challenges of designing unpredictable engagement experiences

This brings me to a critical tension that arises in any attempt to make science engagement events open-ended and emergent. Simply put, it is paradoxical to try and *design* free forms of engagement that follow no rules and can go in any which way, through any imaginable medium. How is it that one can *plan* for emergence? As I have shown, science communication theory is full of principled arguments that make the case for why open, reflexive and emergent communication is more desirable than prescribed forms of engagement. But how is it that science communication experts can prescribe something that is inherently non-prescribable - open-ended emergence - as the mode of engagement that will help practitioners do science engagement "better"?

I do not think one can prove that open, reflexive communication is necessarily "better" than other forms of communication in engagement settings. Rather, this hierarchy of "better" only makes sense when an engagement practitioner has clearly defined what it is that they want their communication event to do, and then look for suitable means to attain that end. In chapter one I explained that science communication always has a purpose, and depending on what that purpose is, deficit, dialogic, emergent or

other forms of engagement will be best suited to the needs of the project. In the case of my PhD research on synthetic biology, the theory I employ about its interdisciplinary research networks, power asymmetries, synbiophobia-phobic narratives, imaginary publics, speculative futures, as well as the unstable role of art, design, and open practices like biohacking that can be exercised to promote in the field, has bestowed upon me a political and aesthetic preference for emergent, reflexive and unpredictable engagement that I'd like Aurator to achieve. I designed Aurator with this ambition in mind, however the methodology I use is based in a paradox of *planning for unpredictable emergence*, and so brings with it considerable challenges on how to actually carry out this seemingly contradictory feat. I will reflect upon these limitations and challenges in my discussion chapter, where I will also describe the degrees to which I met my goals for Aurator along these lines.

Chapter 3: Methodology

Research questions

In this thesis, I use a constructivist approach to find answers to two research questions as they relate to my study of science communication with a focus on synthetic biology. The first research question that I seek to answer pertains to a type of subject I have given a name: communicating experts. For my purposes in this study, I use that term to refer to a specific set of multidisciplinary individuals involved in synthetic biology who have agreed to participate in my research. These are individuals who possess deep knowledge about their particular domain of work or activity, such as social science, synthetic biology, biohacking, art, etc. as they relate to synthetic biology, and who also willingly communicate about their knowledge with others. In the context of their participation here, as this methodology will make clear, they are communicating about what they know, think, and feel with me, through interviews and audio diaries, the latter of which they understand are to be made public online. These communicating experts understand that they are participating in a science communication experiment when they are cooperating with my requests and prompts in this project; they also understand that they are the communicating subjects I want to draw stories and information from. Therefore, communicating experts know that they possess particular knowledge, know others want to hear about it, and know that they are actively engaging in communicating about that knowledge with different audiences in both interpersonal (them with me) and public (them with others) formats.

Now that I have described who these communicating experts are, I can outline my research questions, which follow:

1. How do the emotions and affects experienced by communicating experts in science communication productions that publics will eventually engage with, shape how they inhabit their roles as communicators?

2. How do the emotions and affects experienced by the public engagement practitioner (the producer of the engagement event) shape the outcomes of the engagement event?

To expand briefly on these questions before elaborating further, in this study I employ practice-based research rooted in interactive documentary and audio diary methods to investigate how emotions and affects shape the way that communicating experts take up, transform and resist their roles as actors in a public engagement event. I also investigate how the emotions and affects that I experience as the producer of the engagement event shape the output of engagement. Lastly, I discuss my experience and process of conducting this research and noticing how it travels in the lives of the communicating experts and my own life. I make some conclusions about what such an approach to science communication offers practitioners in terms of how we can understand how to care better for our engagement events as well as our participants. In this thesis, the communicating experts are also sometimes referred to as *diarists, research participants* or *research subjects,* because they are all synonymous terms.

A note on the limits of my case study for analysing these questions

Using Aurator as a practice based case study is limited in its potential to generate data for analysis from which I can fully answer my rather broad research questions as they relate to science engagement on the whole. Indeed, the sample size of diarists is relatively small and the mode of participation they were invited to partake it by making audio diaries is not representative of how science

engagement normally takes place in the "everyday" world of science communication (for there is no normal in this regard, but a plethora of options). Despite this case study's specificity, I use it to try and answer clear but broad research questions about the function of emotion and affect in science engagement productions. This raises some serious challenges in terms of how suitable this singular case study is for the task of answering such broad questions.

I fully acknowledge that this case study will not be able to reveal *all* of the functions of emotion and affect in the production process of science engagement events. Nor will it uncover aspects of their function that are guaranteed to be generalized and repeatable across different models and formats for engagement. However, this is an unique case study in that it highlights the role of intimate research methods (which I will discuss). Intimate research methods are a helpful framing through which the complex interpersonal interactions that are always a part of science engagement productions, but are often extracted from their analysis or not accounted for, can be made explicit and discussed. Without getting into the specifics of an engagement case study such as Aurator, few insights could be made about what happens when intimate methods are used in public engagement. These methods reveal a lot about the function of emotion and affect, contributing to our knowledge of how they shape production processes, but I do not claim that the lessons learned from this case study will be able to benefit all practitioners regardless of how they choose to carry out their engagement projects. Instead, the lessons learned here will describe how certain sensibilities for production function that practitioners may consider applying to their future engagement projects. The case study offers practitioners new things to think about, but by no means does it promise to be a one size fits all approach to doing engagement ethically or doing engagement "right".

A note on the limitations of affect and emotion

In this dissertation, I look at affect as intensities, forces or feelings that lead to *making a difference*, as laid out by Mary Wetherell's two-layered definition of affect (which is inclusive of emotions) already explained in chapter one. Because her definition includes an account of emotions in its first layer, I will often refer to my analytical interest as being in affect (not affect and emotions) from here on in, assuming that the reader now understands that this includes a consideration of emotions where they arise. However, in instances where it is suitable, I will discuss explicit emotions. I identify affect in my research data when differences are being made in how my research subjects – or myself – are acting, as well as when emotions are being clearly communicated by the research subjects or myself.

I use my own body as a vessel through which this knowledge of *making a difference* can register by paying attention to what is happening within me and within the diarists as we engage in the project over time. But it is worth noting that using my body as a medium through which to notice data worthy of analysis and use in the practice-based part of this thesis is obviously limited; it is highly subjective and context dependent. My mood, pre-influenced by factors other than this research, such as for example by things I'd experienced on a given day, could determine how I react to data while analysing it. Furthermore, my awareness of the importance of a discursive point a communicating expert may have made in the data could cause me to take special interest in it and *find it affecting*, while others with less familiarity of the synthetic biology literature might not take any notice. Therefore, there are flaws to my method of using my own body as a vessel to register affect through. These include but are not limited to the constraints of my intuition, the extent to which I have obtained knowledge about the matters of concern in synthetic biology discourse, and my vulnerability to massively complex external factors such as personal life experiences or values and beliefs that could influence the way I perceive data.

Despite these limitations, I chose this method because I am not unique in being trapped by these complexities. This is not a scientific research practice I am engaging in, but an analytical practice that feeds a creative media practice and visa versa. My practice is carried out with the hope that other people may come to be affected by it and somehow engage with what it is doing. That matters because those imagined others – the people who show up for science engagement experiences - will also be challenged by their own subjective limitations to noticing when interesting things are happening in communication settings. I therefore use my body, my intuition, and my unstable modes of perception to analyse this research for *affective* and *affecting* moments. I do this not because they are the most accurate tools to do so with, but because they are the most commonly applied parameters in the everyday world of science communication as people try to make sense of what is being said (discursively and non-discursively) in whatever science engagement events they encounter. I search the transcripts of interviews, audio diaries and my research journal for words that are explicitly related to feelings, emotions, moods and affecting personal experiences to identify where affect is clearly *making a difference.*

With this idea of "affective engagement" I would like to highlight the experience of embodied intensities as something to be valued in science communication. These intensities are not necessarily inherently counter to rational thought, they could form a part of it, and our understanding of how this works may be historically dependent (Brown and Michael 2002). Without getting bogged down with binary categories such as rational or irrational, I want to look for how affect matters to the way that science communication is produced (consciously and otherwise). If science communication can make someone feel such intensities, which might go on to generate emotions (laughter, disgust, sadness, etc.) - as it sometimes does - then connections between actors in engagement experiences might be made, strengthened, or perhaps even jeopardized. This connects to Sarah Davies' call for attention to the embodied, material and sensorial dimension of subjective experience in public engagement projects, which

I wrote about in chapter one. That includes engagement that does not shy away from big emotions, hard recognitions, overzealous thinking, impactful memories, life-changing events, harsh opinions, descriptions of biases, and more - in other words a whole spectrum of affects and feelings about science. What might that enable or put at stake for those who are communicating? And what might that enable or put at stake for public engagement events more broadly?

Intimacy in research

A number of volumes have been published in the last few years that explore issues of methodology and intimacy, in as much as they are about how to conduct research *on* intimacy (e.g. McGlotten 2013, Paasonen 2011, Payne et al. 2014). Often these projects are concerned with researching intimacy interpreted as a sexual or familial phenomenon. But intimacy, as it is entwined with methodology, is also about how intimacy functions *in* research, as emotional, sensory relations become tethered to how research is conducted and therefore form an invisible part of translating that research. As Fraser and Puwar have argued, "these processes inform the making of knowledge, shape power relations and enable or constrain the practical negotiation of ethical problems." (2008: 1). While designing research plans, making decisions about how to gather sensitive data, and interacting with participants, a wide variety of feelings may be generated that complicate, trouble or enrich what knowledge is possible to be gained. As researchers, we "carry the smells, textures, pains, desires, sounds and the visual store of memories of the research encounter with us, from the points of collection, to analysis and public presentation" (ibid: 2). Therefore, the multi-sensory elements of research are felt, somehow processed, and end up part of the project.

In my research, I have, on multiple occasions struggled to negotiate between my mixed identities as a scholarly researcher, research subject, media producer and my relationship to my research

participants over time. There is, in a sense, an invention of intimacy in this research that I have created due to my multiple identities and differing relationships to the diarists that shape the power relations that guide how this research was done. These are often difficult realities to discuss and account for. At times, my experience as a professional public radio producer has equipped me with tools that help me negotiate the terrain between myself as the information seeker and my subject of interest (interviewee/diarist), through my developed sense of an "interviewer's intuition" rather than any specialized training, which I write about in my analytical chapters. But in scholarly science communication research, sources for this way of "feeling for your subject" run dry. I discuss the limitations and opportunities practice-based research opens up for legitimizing intuitive ways of knowing in science communication scholarship in my discussion (chapter six).

As scholars have argued, instead of diving into the murky affective space between researcher and participant, the issue of intimacy in research gets ignored in order to make stable disciplinary claims. As example of this appears in Simon Cohn's work where he writes about how neuroscientific images of emotions are created through a dynamic relationship between researcher and subject, although "the special kind of intimacy that is established between researcher and researched…later gets extracted as artifactual noise." (Cohn 2008). In my project, intimacies were created from the moment I started enlisting diarists as participants, to the points when some of those relationships broke down over time and participants backed out of their roles. It is undeniable that layered intimacies have been produced through the course of research transitions in this project, which I will try to account for in my analysis along the way.

Theoretical framework for producing an original public engagement project

As I have demonstrated in chapter two, synthetic biology, as a field, is sometimes vulnerable to synbiophobia-phobic approaches to public engagement that aim to ensure public trust and engineer public acceptance of the field and its industrialisation (Marris 2014, Hagen 2016). This is important because

scientific institutions that try to appear trustworthy through public engagement "hit the notes but miss the music" as Brian Wynne has argued (2006). According to Wynne, scientific institutions often imagine their publics as they try to engage with them as a means of restoring public trust, rather than listen to them honestly first in order to foster meaningful engagement experiences that respond to their genuine concerns and feelings. Scientific institutions that "hit the notes but miss the music" imagine that their publics' "deficits of knowledge" are their basis for their mistrusting science. For example, they might think that publics are scared and mistrusting of "uncertainty" in science because they are ignorant of how science works, which is itself always full of uncertainties, and consequently they imagine that the publics they seek to engage will be either unambiguously pro or anti-science and technology depending on how much they understand about how science works *before* they engage with them. Connecting to this, Wynne also points out that the conventional literature about science engagement tends to ignore how scientific knowledge "*performs* its imagined publics in normative ways and reflects its imagined publics, its commercial reference groups and meanings in its own culture." (2006: 219).

What I take away from Wynne's arguments as most important for my study here, is that it is futile for anyone to try and instrumentally engender public trust in science. When public engagement, participation, dialogue, or other means of building a relationship with publics are created with the explicit aim of making publics come to trust science, a striking fallacy appears. The fallacy is not the instrumentalization itself but the idea that scientific institutions can instrumentalize public engagement while deceiving themselves that they are actually listening to publics because "it is a contradiction in terms to instrumentalize a relationship which is supposed to be based on trust." (2006: 219). The only thing that an actor in an engagement event has control over is *their own level of trustworthiness,* not whether or not others will trust them, because trust and credibility are not inherent qualities of the speaker, they are qualities that

others will judge about the speaker for themselves in emergent ways that relate to their own knowledge, values, experiences and belief systems.

Considering this, Wynne offers some words to the wise about what scientific institutions might be able to do on the issue of trust, taking for granted that trying to engineer it is a futile endeavour:

> "Institutions could cultivate their own trustworthiness, as the closest they could *guarantee* to get to public trust, by being openly self-aware and questioning – 'self reflexive' even if always to an imperfect degree – about their own imaginations and assumptions of science (which would include lack of control) and of publics." (2006: 220).

I am convinced by this suggestion, that what is better for scientific institutions to spend their time and energy on when engaging with publics is to try and genuinely improve their own *trustworthiness* rather than focus on how to most effectively force square-shaped publics into a round-shaped hole that they call *trust in science*. Considering synthetic biology's vulnerability to imagining its publics are synbiophobic before they learn who those target publics really are and what they really have to say – I searched for science communication tools and theories that would allow me, as a practitioner, to create a space where communicating experts in the synthetic biology field can demonstrate some of their own reflexivity about the science and its publics. Might this be a way for synthetic biology to explore its own *trustworthiness?*

It has been suggested that if scientific institutions can demonstrate their own commitment to making deliberative processes transparent, they will be seen as more trustworthy in the eyes of others (Power 1999). Transparency might take many different forms, such as: informational transparency that requires all information on which decisions get made is disclosed; participatory transparency, ensuring public participation in all decision-making processes; or accountability transparency, where decision makers are always held accountable for their actions (Balkin 1999). However, the attempt to be transparent and demonstrate one's transparency to others is increasingly dogged by the scepticism of participants and

publics who may see those efforts as calculated to try and win them over (Brown and Michael 2002). Therefore, an element of trust in the scientific institution may need to be there from the outset in order for "transparency acts" to appear genuine and trustworthy to others. But when a scientific institution is trying to demonstrate its commitment to transparency in order to build real trusting relationships with publics, because it lacks them, how is it to overcome this cycle? It operates similarly to trying to get your first job, when all prospective employers require you to have some work experience. Transparency, it would seem, is not a magical potion for demonstrating trustworthiness, and is itself subject to inherent limitations.

Brown and Michael suggest that one way to break the cycle is to move from a position of authority to 'authenticity' "and in particular, authenticity signified by suffering, pain, agony and the like…this discursive and practical repertoire of feelings, emotions and affect serves to signal authenticity or genuineness which in turn serves to establish transparency and openness" (2002: 2). This, they argue, is because suffering is based in the dilemmas that one experiences when they have opened themselves up completely to different points of view; it is full of tensions that emerge when a person or institution attempts to incorporate contradictory or antagonistic positions into the way that it does things and assesses its own activities. "In other words, the encompassing of these contrasting viewpoints leads to pain: crucially, the 'experience' and performance of sufficient pain conveys the impression that one has encompassed as much contradiction as is possible – one has been open and transparent enough." (ibid). The idea is that by sharing the discomfort and stress that a scientific institution has experienced, it signals to others that it has agonized about how to make tough decisions, while trying to incorporate as many disparate positions as is bearable. This pain is authentic, and it relies on emotions – *on behalf of the scientists or scientific institution* – to perform itself. And emotions are seen as inherently genuine, they argue, because "Western culture is characterised by a predication to view emotions as inherently genuine, naturally occurring cognitive forces over which the individual has little rational control (ibid: 5).

It would be naïve to think that if a scientific institution or group of scientists simply express their own suffering, that publics will judge their openness and transparency as credible and genuine, as if there is a direct correlation between these traits in all imaginable scenarios. However, the focus Brown and Michael's argument puts on science performing its own feelings, emotions, and affects is of great interest to my study and directly ties in with my research questions. It feels to me, on an intuitive level, to be an argument with bite. The very reason why politicians can feel slimy sometimes when they're speaking diplomatically is because they specifically do not put any emotion or personality into what they are saying, and by doing so manage to say nothing at all. As a practitioner, I am creating a place for emergent forms of engagement about synthetic biology to take place, that acknowledges the affects experienced and produced by communicating experts as I try to understand what effect their feelings have on their participation, my production choices, and the overall outcomes of the experiment. Therefore, as I embarked upon my research design, I used Wynne's argument that public engagement that aims to engineer public trust "hits the notes but misses the music" and incorporated it with Brown and Michael's suggestion that the more room a scientific institution has to express its own emotional experiences, the better the chances for authentic engagement will be. And so, I set out to design an experiment that would allow my participants – the communicating experts – to express as much of their own feelings as they were willing to, in a platform where they can eventually be met by publics as complex emotional beings.

In order to this this, I needed to work with a model of science communication that is not prescriptive in terms of what various parties will get out of the engagement event (such as "more knowledge" as the deficit model would expect publics to receive, or "mutual understanding" as dialogic models of communication would describe). Therefore, I frame this study using Horst and Michael's "emergence model" of public engagement (2011), which I described in chapter one, because it is a model that explicitly characterizes how non-prescribed engagement events can take place. To recap, the

emergence model they propose is different from deficit and deliberative models of science communication because it does not privilege the direction of information flow, nor does it privilege any stable medium through which communication allegedly happens. The emergence model looks at communication as an unstable process, because "the entities themselves are seen as mediators, that is, as actants who change, and are changed through, the event of coming together." (2011: 86). It is therefore open to unforeseen and unprescribed meaning and knowledge to emerge from engagement experiences, in multiple directions beyond the notion of "sender" and "receiver." Importantly to my study, it is also a model that is open to emotions and other non-discursive elements of communication being substantive of engagement processes and events. This model allows me to notice how the material conditions of a particular engagement event, such as duration, surroundings and emotions affect how communicating experts engage with my science communication experiment, as well as notice how those material conditions affect me, which in turn shapes the overall outcomes of the engagement as well.

Operationalizing the emergence model with polyphony

As will become clear, in this thesis I am combining theories from the social sciences, humanities, and media studies (such as radio and interactive documentary) into a cohesive framework that can be applied for making and analysing science communication production. Particularly, I operationalize the emergence model of science communication in my practice-based research process by using methods that allow for the "unfinalizability" of engagement about synthetic biology. If engagement on synthetic biology were able to "finalized", and by that I mean, crafted by some declarative and authoritative voice on the matter, the engagement event would certainly be prescribed by that voice's values, beliefs, experiences and attitudes, and would risk taking a deficit or dialogic approach to its communications. Here I am trying to open up discourse about synthetic biology through emergent, non-prescriptive formats for engagement

that make room for emotions, affects and feelings to be shared. This means that I must navigate the inherent limitations of using a method whereby I am *planning* for *unpredictable* and open emergence – as if it were even possible to *design* something that has zero constraints or parameters. I do this, to the best of my abilities, by choosing methods that resist the "finalizability" of discourse and are open to dissensus (as opposed to consensus). This is the research goal that led me to use "polyphonic" production methods to make the interactive audio documentary that is the basis of this study's practice. I will return to explain Aurator shortly, but first I must explain what I mean by polyphony.

I employ the term here in the way that the 20th century Russian literary critic Mikhail Bakhtin used it to describe the phenomenon of "multi-voicedness." In his view, an individual human consciousness on its own cannot generate a sense of self because subjectively, one never coincides with themselves. An individual's worldview is never completed, but rather stuck in a loophole until it finds meaning through a process of shifting combination, whereby one's partial understanding comes together with the partial understanding of another consciousness to amount to a greater sense of self. Bakhtin called this an "aesthetic event." Bakhtin writes, "An aesthetic event can take place only when there are two participants present; it presupposes two noncoinciding consciousnesses." (Bakhtin in Holquist and Liapunov 1990: 22). But this "aesthetic event" - between two or more consciousnesses - is not a static process of completion. Instead it produces an unfinalizability of discourse, which keeps morphing as others' partial experiences add to it over time (Morris 1995: 6). This, for Bakhtin, is the essence of discourse in action, and a fundamental characteristic of the human condition.

Bakhtin extensively studied the novels of the Russian author Fyodor Dostoyevsky. He was compelled towards Dostoyevsky's writing, which he saw as influenced by many diverse, conflicting forces based on the interests of multiple individuals. To explain this, Bakhtin coined a new term – polyphony – which describes the signature narrative form that Dostoevsky used in his characters' dialogues. Polyphony

is based upon a premise of multivoicedness, and describes Dosteovsky's signature approach to writing novels in which his characters would speak solely for themselves and their own agendas (with their own ideas and opinions) and not speak in ways that could be construed as acting in the service of any other character's agenda or opinion. This created an unfinalizability of discourse through a collection of many voices that each have their own distinct position and ideas to contribute. Bakhtin writes of Dostoevsky's novels, "A character's word about himself and his world is just as fully weighted as the author's word usually is; it is not subordinated to the character's objectified image as merely one of his characteristics, nor does it serve as a mouthpiece for the author's voice. It possesses extraordinary independence in the structure of the work; it sounds, as it were, *alongside* the author's word and in a special way combines both with it and the full and equally valid voices of other characters." (Bahktin 1963 in Morris 1995: 89).[16] The polyphonic novel is not geared towards well-rounded and finalized narratives. Rather, it is geared towards the places where multiple people's consciousnesses meet; "it lives a tense life on the borders of someone else's thought" (ibid.) Therefore, polyphony, the engine of such a novel, resists the finalizability of discourse by the nature of its very structure.

In an essay called *Discourse in the Novel*, Bakhtin reflects on the concept of how hegemony functions in discourse. He saw hegemony as a power that privileges one unified voice over others, which speaks in consistent perceptions of what it considers to be the truth. In relation to my research, this sort of hegemony is most easily possessed by any scientific establishment with a deficit mindset, which speaks to publics with "facts" about the world that it aims to impress is important knowledge that publics should take in. As I have shown in chapter two, in the field of synthetic biology, experts from non-natural science disciplines such as the humanities or the social sciences do not enjoy the same hegemonic position in the discourse of synthetic biology as natural scientists and engineers. Similarly, when engaging with publics,

[16] Bakhtin, Mikhail 1963. *Problems of Dostoevsky's Poetics.*

scientists and engineers occupy a hegemonic position in the exchange if publics are expected to either soak up what the experts have to say, or simply respond to it deliberatively. What these relatively less hegemonic voices do is nuance what natural scientists and engineers have to say about synthetic biology through the questions that they ask and the discussions that their efforts open up. Bakhtin attributes this ability to nuance, co-mingle with, and diversify a unified hegemonic voice to a force he calls "heteroglossia." The Bakhtinian scholar Pam Morris writes of this,

> "Within language there is always at work a centripetal force which aims at centralizing and unifying meaning. Without this impulse the shared basis of understanding necessary for social life would disintegrate. This centripetal force in discourse is put to use by any dominant social group to impose its own monologic, unitary perceptions of truth. However, always working against that centralizing process is a centrifugal force – the force of heteroglossia – which stratifies and fragments ideological thought into multiple views of the world." (Morris 1995:15).

In this way, any monologic truth claims made by one voice or group will be relativized by the existence of other views of the world that are spoken by other voices, as they are in the polyphonic novel. Therefore heteroglossia, much like polyphony, brings about the 'destruction of any absolute bonding of ideological meaning to language." (Bahktin 1935 in Holquist 1996: 281). Therefore, Bakhtinian theory demonstrates how polyphony and the associated concept of heteroglossia prevent prescribed engagement through language from taking place, allowing new meaning to constantly unfold with each additional "aesthetic event." Polyphony, as the grounds for engagement, therefore fits into a communication model based on emergence as its primary mode of engagement.

Operationalizing polyphony with participatory interactive documentary

Participatory documentary online is a type of documentary making that evolves over time with user-generated content from individuals who experience the documentary on the web (Aston and Gaudenzi 2012). The users may generate parts or all of the content involved in an interactive web-based

story by contributing video, audio, text and image content to it (O'Flynn 2012, Nash 2014). Participatory interactive documentary is a particularly well-suited method for practicing polyphony with media (Aston 2009). Before I explain this further, I must define the overarching category of interactive documentary into which it falls. Online interactive documentary (hereafter "i-doc") is an emerging medium for communicating multimedia nonfiction narratives (Choi 2009). Defined from a functional perspective, interactivity here can be understood as "the user's ability to directly intervene in and change the images and texts that they access," whereby the user is the individual experiencing the documentary (Lister et al, 2003: 20).

In her doctoral thesis, Sandra Gaudenzi describes various emerging forms of i-docs appearing on the web and assembles them into sense making categories. Gaudenzi notes that the commonality across them all is that i-docs tend to be platform specific (as in made for mobile, tablet, social networks, personal computers, etc.) or user-centric (personalizing the story for the user based on their participation or data analytics). She points out that the fundamental difference between a linear and an interactive documentary "is not the passage from analogue to digital technology but the passage from linear to interactive narrative." (2013: 32). Both forms of documentary try to establish a dialogue with reality but the media they use enables different outcomes. If linear documentary requires the attention and therefore cognitive participation of the viewer, the i-doc requires an additional physical demand of its viewer that must navigate the story on its web-based platform (turning them into a "user") such as clicking, moving, speaking, commenting, etc.

Interactive artifacts in an i-doc may attempt to shift the worldview of the user who has just experienced it. In other words, the design of interactivity in an i-doc carries enormous weight over the meaning of the stories they tell. The extent to which interactivity gives the user control over the story's content will shape whatever knowledge is made possible for the user by interacting with the work. As

Gaudenzi argues, "The introduction of interactivity, through new media, brings with it new dynamics which, with time, creates new possible aims and therefore new epistemologies." (ibid: 36).

Where linear documentary classically allows reality to be represented from the 95uthor's point of view through an "act of persuasion" that is crafted by the way it is framed, shot and edited (Nichols 1991: 103), web-based i-docs have, from a very early stage in their history, offered a different authorial perspective. While the author can still try and persuade their audience of a specific point of view, they can also step back and allow the user's points of view to shape the story world themselves. In i-docs that pull live data from the internet and assemble it through an interface, such as Jonathan Harris and Sep Kamvar's project We Feel Fine (2005), which searches the internet every ten minutes for expressions of human emotion on blogs before displaying them dynamically in an artistic interface, the authors are not as much the evangelical promoters of a point of view as they are facilitators of an experience for their users. We Feel Fine uses crowd-sourced content, which may also be user generated in the sense that a blog's author could find themselves on the We Feel Fine project website, navigating a flurry of emotional highlights from millions of blogs, wherein theirs could at some time appear. Where the i-doc creator is not aiming to tell a story from a single point of view, success may instead lie in their creating an interactive platform where different users can see, hear, or meet each other as a way of mediating society and a certain issue bound up in it (Dovey and Rose 2012).

The internet affords unique storytelling techniques made visible in i-docs by connecting diverse users to a story at different times and at different speeds that are determined by their own behaviours (for example, they may visit the website of an i-doc only once or they may repetitively return to the site over several months to explore more and more of the story each time they do). This durational aspect of i-docs – whereby they stay open for exploration over long periods of time in a format that publics can return to – makes them especially well geared towards participatory modes of public

engagement with science. Powell and Colin have argued that there is a growing dissatisfaction with the one-off, stand-alone nature of much public participation. When engagement is not durational or continual, people might fall off the wagon and lose motivation to care about the scientific issue at hand. They question if it is possible to have constructive short-term exercises with a high potential for impact on scientific decision-making between laypublics and scientists, when expertise varies so widely and there is no meeting place for people to continue participating once the event is over. The material conditions of the engagement matter here, where the time to build stronger relationships between those participating could make all the difference. As Powell and Colin argue, most face-to-face participatory exercises have only very short durations, which can have a discouraging effect in terms of creating the right conditions for further engagement (2009). But when the forum for participation is moved online into an i-doc space, relationships, deliberations, and discussions can continue to emerge between experts and publics. They don't disappear, and in theory, can be returned to for deeper engagement over a greater durational timespan than a one-off event.

The solicitation of user-generated content in interactive participatory documentaries may be highly structured, semi-structured, or quite unstructured, after which the challenge for the producer becomes how to include user-generated content in the i-doc without jeopardizing its coherence. But it is important to note that participation is not the same as interactivity. If a user clicks a hyperlink in a webpage, they don't necessary change the contents of the documentary. However, if a user's web browsing history is taken into account and changes the plot line by determining what comes next in the documentary, then their participation has changed something about the story. Furthermore, if a user specifically comments or makes a recording that gets added to the story as user generated content, then the user directly changes the media comprising the interactive documentary. So, participation is a specific mode of interaction in the documentary context, not a synonym of it.

Gaudenzi points out that participatory online i-docs don't just inform audiences but create unique effect by "changing users into co-producers and creating a dynamic of co-responsibility and polyphony towards the reality that is portrayed by the documentary." (2013: 36). The fact that Gaudenzi used the word polyphony in her explanation was a helpful omen when I came across it in her thesis, but the link to my theoretical framework would have still been clear if she had not used the term. Participatory i-docs that grow and change with user-generated content establish a multi-voiced dialogue between different individuals in society (users) around a factual topic, which are continually comprised of an "aesthetic event" in the Bakhtinian sense. Every time that a user uploads a new piece of content or a media file of their own making to the story world, their consciousness is added to the growing collection of consciousnesses already embedded in the project, and they contribute to the heteroglossic force within the project that resists any one authoritative voice from speaking declaratively about the subject of the documentary. In my case, creating a participatory i-doc as a part of this thesis provides a gateway into enabling diverse publics – including communicating experts and non-expert publics – to have emergent discussions about synthetic biology that do not draw borders in terms of what they are able to explore. In this sense, the participatory i-doc provides a literal interface where polyphony can take place.

Therefore, the participatory i-doc, as a media format, enables documentary producers to establish polyphony in practice, at least in theory. Of course, there are always practical limitations to how theoretical impulses are translated into material practices. But possible limitations should not stop a practitioner from attempting to incorporate theoretical research into the way they design their practice. In this thesis, I designed and created an audio-driven participatory i-doc called Aurator, which allows different users to listen to each other's audio diaries about synthetic biology in an "unfinalizable" way as Bakhtin described it. Participation occurs when users upload their own user-generated content in the form of audio diaries or audio responses to expert diaries, to continually add to the documentary's heteroglossic force.

This makes the polyphony larger and more active as each new voice adds something to the engagement experience with its own set of feelings, beliefs, emotions, values and subjectivity tied to it. Aurator's production process and its comprising media form the data that I analyse in order to answer my research questions.

Operationalizing polyphony with audio diaries

In order to gather the "many voices" that are needed to establish polyphony in my participatory i-doc, I used audio diary methods: a subset of traditional sociological and anthropological research tools known as diary methods. Everyone has kept a diary at some point in their life, or at least, everyone understands how they work. By recording one's personal thoughts and feelings, most traditionally in writing, a diary entry is made. When that is done over time, it becomes diary-keeping or diary-making, something akin to journaling - a practice people have been doing for hundreds of years. The solicitation of diaries from research participants, as a methodological technique, is also nothing new. Over the last several decades, the social and health sciences in particular have developed the use of solicited diaries as a reliable qualitative technique for longitudinal data collection. But even so, "diary method" has lived predominantly beneath the limelight of its more often chosen counterpart - the interviews - as a research tool (Bartlett and Milligan 2015). Like interviews, diary methods exist in multiple forms: structured, semi-structured and unstructured, which like all methods, each have their own associated practical issues, opportunities and limitations. Though on a general level, diary methods have been defended for their ability to capture rich data about subjects' personal experiences, feelings, and beliefs over time without much disturbance from the researcher since the process of diary making is mainly controlled by the subjects themselves (ibid).

With the advancement of digital technologies, the tools at a researchers' disposal to solicit diaries from participants has become dramatically diversified. Blogging, social media, smart phones and

other digital devices all create avenues for recording subjective thoughts over time that can be transferred easily between participant and researcher. These platforms have conveniently and affordably extended the possibilities for recording diaries in formats beyond the written word to include digital media, such as video and audio recordings. In this research, I utilize audio recordings as a diary method whereby diarists keep track of their feelings and thoughts about synthetic biology in self-made audio recordings once a week over a twelve-week period. In this sense, the particular diary method employed here becomes one of "audio diaries" - a concept I was previously only familiar with from a radio show and podcast that I used to regularly listen to called *Radio Diaries,* which I will shortly come back to. But first, a brief note on the limitations of diary methods.

Limitations of diary methods

Some limitations of diary methods pertain to the various kinds of burden that they can put on participants. This often includes a necessary training session that is very detailed and possibly time consuming in order to ensure that the diarists know how to complete the diaries (whether they are to be written, recorded in audio or video, etc.) in a way that will yield good data for the researcher (Reis & Gable 2000). Indeed, I made an instruction video for my diarists that I sometimes had to ask them to re-watch in order to learn the diary recording protocol correctly. Due to the fact that I didn't get to meet the majority of my diarists face to face because of our physical distances, training them properly on how to use the electronic recording equipment proved to be a difficulty that had significant implications for the project and research overall, which I write about in my analysis. Also, diaries may become onerous to complete for participants if they are asked to do them many times throughout a study, however, structuring the diary process so that they can schedule around their diary entries may help alleviate some of this burden as compared with giving them a completely random schedule, as random schedules may lead to postponing

and procrastination (Bolger et al. 2003). Diaries may also put burden on participants to recount things that have already happened in the past. When this happens, they may give "aggregate" responses, meaning that they regurgitate a lot of information all at once based on peaks of the experience that they can remember, while skipping over lots of other interesting qualities about what may have occurred. These kinds of aggregate responses may "reflect faulty reconstruction of the phenomena of interest" (Bolger et al. 2013: 581). The content or stories that are recounted in a diary may also be highly susceptible to "state-congruent recall." That is, the current mental state the diarist is in will shape and colour the way they make sense of their memory of a past event, meaning that they report it differently than they would have if it were happening currently (Bower 1981). The complex ways that human memory functions raise issues of accuracy for diary methods, but not necessarily authenticity, as a diarist may authentically be recalling what it is they think they know.

Audio diaries in public radio

I first became familiar with the concept of audio diaries in American public radio producer Joe Richman's award-winning National Public Radio (NPR) series *Radio Diaries*. This work is widely listened to by public radio fans in the United States (particularly) and internationally (more generally). *Radio Diaries* finds real-life participants with interesting stories to tell who record their own lives over the course of a year without the producer being present. In the 1990s, Richman created a series called Teenage Diaries, where he provided tape recorders to young people across America. He then asked the teen diarists to conduct interviews, record their own audio diaries as spoken journal entries, as well as record the environmental sounds of their daily lives. In *The Teen Reporter Handbook*, Richman explains that more than 30 hours of raw tape is usually recorded by each teenaged participant over the year, which are then edited into the 15-30 minute documentaries that would air on NPR's All Things Considered.

The first time I heard the Teenage Diaries series, I was mesmerized by its ability to bring the listener directly into the most intimate moments of a stranger's experience – a teenager's experience of all things - such as the moment when a Catholic school girl tells her homophobic parents that she is romantically interested in women and then records the ensuing aftermath, or the daily social interactions that a teen with a stutter experiences at school. These scenes would not have been captured nearly as effectively, or at all, if a producer were there, largely because of the logistical and emotional constraints of having a witness there. As such, an attractive quality of the audio diary method is that it ensures that the subject's point of view is not mediated or obscured by the producer's presence.

Furthermore, the appearance of a recording device - such as a camera or large microphone - that has someone (or a whole team) attached to it in order to operate the technology correctly can make a subject feel self-conscious of their own performance. That self-consciousness can show up in how they form their responses and therefore affect the overall media production that relies on the recordings they are featured in. It is not controversial to say that self-consciousness can create situations where one might feel constrained, and therefore may behave less naturally, or sound less "off the cuff" while speaking - all of which are not ideal head spaces for an interviewee or storyteller of any sort to be in. In my experience working as a radio producer, we always strive to have an interviewee sound as much like themselves as possible in order to maximize their ability to sound captivating to a listener. As listeners, we can read a lot about the emotional state of a speaker through the tones, pacing and intonation of their voice. Therefore, it is a stylistic (and ethical) choice that a producer makes when they design an interview scenario that tries to put the interviewee as much at ease as is possible.

In my radio productions, I always to try to capture the sound of someone's voice in its most authentic state of performance - by this point it is basically radio dogma for me to do this. Multiple mentors over the years have taught me the importance of working with the naturalistic style of the speaker.

They have always explained that the potential to transmit real emotion has the power to affect a listener, and is therefore more likely to cause them to keep listening. A natural tone in one's vocal performance has always been my aesthetic preference for audio stories. It doesn't only benefit how the subjects in an audio story come off to others if they manage to be natural, but the broadcast journalist as well. As Ira Glass, presenter of "This American Life" has argued, it is vital for broadcast journalists to sound like "human beings on air" rather than "know it all stiffs" in order to retain their audience in a media landscape where fact-based journalism is suffering (Glass 2011). The ability to sound like "human beings on air" is best captured when someone talks just as they would over a meeting with a friend. The ability for most people to transmit that sense of genuine self and emotion through their voice often gets diminished if they read from a script, try to sound like an idealized version of themselves or try to emulate another character. What I'm getting at is not an academic science of radio making, but a "feeling for the tape" that we develop by recording and editing interviews with our documentary subjects. This sensibility also collects over years of discussions about aesthetic audio preferences with other radio makers. It is an intuitive sensibility that I discuss at much greater length – in terms of its challenges and affordances when doing scholarly work – in chapter six.

The method I designed for this study cannot be disentangled from audio storytelling sensibilities I've developed from years of working in radio. Rather, I try to be explicit about those sensibilities where they appear and back my "practitioner experiences" up with scholarship where it is available. My efforts to record the communicating expert's most natural expressions is above all relevant here because I am seeking to understand how they inhabit their roles as genuinely engaged (or disengaged) participants during the production of an original science communication media project. I will be listening to their voices for information about their own affective and emotional state in order to analyze what happens during the production process.

The affective power of voice

The textures and shapes of a voice can carry and transmit significant emotional information. Radio scholar Siobhan McHugh describes this as the "power of voice" (2012). Emotions get "communicated aurally to listeners by the many and changing tonal aspects "of a voice that's telling a story" (ibid). Discussing one of her own radio documentaries, McHugh explains how an interviewee who once recounted a traumatic personal event to her transmitted emotions so intense through her voice that McHugh felt the intensities of the original event herself: "her taut delivery, her uneven breathing, her gulps and sniffles as she struggles to describe what happened. These, in turn, trigger an affective resonance with listeners." (ibid). She argues that the affective power of sound and voice means we can be moved by listening, which is not a value neutral process. The ways we are moved by listening to a story then go on to influence "how we absorb and retain its content, as well as how we judge that content." (ibid).

Elsewhere McHugh writes about her experiences observing a workshop for print journalists who had never worked in audio but wanted to transition to using radio as a journalistic medium. She writes that the journalists "gradually came to understand that audio storytelling had a completely different grammar and logic than print… the journalists were astounded by the difference the medium made – the emotion that could be conveyed in a voice, that did not need flagging by the writer." (McHugh 2017: 2).

However, it is important to note that "the display of emotion can be either genuine or feigned" (Shouse 2005: 5). In this research, my preference is clearly for communicating experts to display their genuine emotions in their recordings, which may come partly through the power of their voices. My dual roles as researcher and practitioner both agree on this. This is not radio drama after all, it is science communication. But the degree to which participants will be able to convey their feelings, moods and emotions genuinely in their personally recorded audio diaries, is beyond my control, highlighting a limit to my data collection methods. Despite that, the communicating experts in this study will be telling their own

personal stories with their own voices. Their voices are vessels for communication that carry special affecting power. When emotion and personal storytelling get combined, as they do in spoken-word audio storytelling such as audio diaries, intimacy can be generated.

The intimacy of audio

I have often heard radio described by media producers as the most intimate medium and a kind of "theatre of the mind." This cliché makes its way into academic writing about radio as well. Orfanella writes "There is an intimacy, a one-to-one connection that no other medium can match." (1998). Tacchi describes "Radio as a medium is immediate, intimate and direct… people often speak of it as a "friend", as "company." (Tacchi in Miller 2002: 26). Shingler and Weiringa discuss "the unusual intimacy between radio and its audience" (1998: 114). Chignell lists several elements that contribute to this feeling of intimacy in radio. These include the way people commonly listen to radio (usually alone), that radio invites listeners to work with their imagination to create the story-world in their minds, that radio announcers usually address listeners directly (such as "Do you ever think about…?" and not "Does anyone out there ever think about…?") and lastly, the fact that most radio hosts are just ordinary people, not celebrities (Chignell 2009: 85). These intimate characteristics of the medium can amplify listening experiences in moving and affecting ways.

In an AMA (Ask Me Anything) event on Reddit that took place in June of 2014, Joe Richman of NPR's Radio Diaries shared some of his personal insights into the intimacy of audio. Richman believes that audio has the power to bring a listener closer to the subject of a story than other media are often capable of doing, which he explained by saying,

> "People talk about the intimacy of radio. It's a cliché, but a true one. It can be like a direct IV into the brain. For me, pictures make things feel a bit farther away. It becomes something we're looking at rather than living, feeling, experiencing. The other cliché is that radio has the best pictures. Somehow, having to create your own images makes them really yours, and makes them stick in some deeper part of your memory." (Richman 2014).

In this sense, Richman describes a mechanism in radio and audio storytelling that functions much like literature, whereby listeners, like readers, must create the visual world in which the story takes place in their mind in order to fill in the blanks of the non-visual medium. Since the listeners or readers co-create the visual non-discursive parts of the story material in their minds, this personal illustrative act affects the way they experience and remember the story. This develops an intimacy that is completely intertwined in the process of listening to audio stories. As Orfanella writes, "Radio has the power to individualize its presentation within the mind of each and every listener. There is an intimacy and shared vision it creates." (1998: 55).

In the AMA on Reddit, Richman also explained why he lets his subjects narrate their own stories in order to produce the most affecting audio, rather than have himself narrate what he's discovered from interviewing them. His choice for doing so is simple,

> "Imagine you're driving home from work listening to the radio (or a podcast…) is it me in the passenger seat telling you about Claressa, a young teen boxer trying to make it to the Olympics? Or is Claressa in the passenger seat, telling you her story? We like stories that put the subject in the passenger seat." (ibid).

Similarly, I believe it is important that I do not summarize what other people think, feel or believe about synthetic biology in my own words when working towards creating affecting public engagement experiences. I choose to not summarize their stories in my own voice order to try and allow their stories to meet their full potential to affect others in a genuinely polyphonic format (how could it be

multi-voiced if I voiced all the stories?). Therefore, I enable my diarists to share their own thoughts, in their own words, to the greatest degree that it may be possible. In any kind of media production, there is always an element of performativity at play that may affect how subjects express themselves. However, I give the control of the recording process that I would normally possess as the media producer over to them so they may capture all their own data, from their own point of view, with as little interruption from me as possible. Richman defends the importance of capturing a subjects' story in their own words, and echoes an often-quoted statement in the AMA to justify doing so when he said: "An enemy is someone whose story you haven't heard." In the discourse of synthetic biology, where conflict about its practices and promises is not uncommon, could listening to audio diaries from diverse stakeholders affect how one thinks about the field overall? Across the lines of professional tensions in interdisciplinary knowledge networks, as well as wider societal discussions about matters of concern, what might happen if we slowed down to really listen to the stories of our "enemies" in different groups who have different perspectives on the science?

In my PhD project, I take inspiration from Richman and equip a group of individuals with audio recorders who work in or around synthetic biology so they can document their own reflections, private feelings, thoughts, and experiences. This group includes: young budding scientists, established synthetic biology researchers, a bioethicist, a bio-artist, a sociologist, a spokesperson for a watchdog group, a biohacker, and an entrepreneur. My hope was that they would capture their own intimate thoughts, moods and feelings on tape as they bubble up in their day-to-day lives, and then I could juxtapose those diverse accounts with each other in an interactive platform for public engagement (i-doc).

Audio diaries in social science research

Audio diaries are emerging in a variety of social science disciplines as a tool for conducting

research, especially in studies of self-perception and how one understands one's own place in life (Worth 2009, Crozier and Cassell 2016). They are partially understood by some social researchers as cognitive tools for psychological self-betterment and self-care and have therefore been promoted as beneficial research tools for research subjects (Crozier and Cassell 2016). Audio diaries have also been shown to help research subjects access cognitive sense-making processes through acts of verbalization (Monrouxe 2009). At the same time, the benefits of audio diaries have been promoted as offering several advantages not only to research subjects but also to researchers, by allowing the researcher to unobtrusively record subjects' experiences through the subject's point of view, enabling immediate data capture and overcoming the reliance on retroactive accounts (as would be done in interviews or even "after the fact" written diaries) (Monrouxe 2009). However, retroactive accounts may also have unique benefits that audio diary methods strip away if they're done too quickly, such as allowing time to reflect between an event happening and reporting on what happened. Extra time might allow for realizing what was truly important about the event, rather than instantaneously saying and capturing whatever comes to mind. Extra time can also be a way of caring for the research subject, by giving them the space and flexibility to structure their narrative(s) in the way that they feel most comfortable with, once those narratives are considered within greater context of their life, identity and social worlds.

Research on psychological stress has theorized that "cognitive restructuring" occurs when stressful events are recalled and reframed as a strategy for adjusting one's perception of those events into something more manageable (Skinner et al. 2003). Storytelling theory has argued that telling stories about recent events can enable the reforming of personal judgments towards such events and one's role in them (McGregor and Holmes 1999). Therefore, Crozier and Cassell have argued that audio diaries may provide a method for "cognitive restructuring" in action, whereby the verbalization of stories about recent events allows diarists to minimize their stress around certain occurrences (2016: 402). In this way, audio diaries

become a way of making sense of one's life and what has happened to them, reconciling difficult emotions into understandings that make life easier to bear. However, this is not a simple prescriptive process. It is plausible that it is not always easy to process difficult recalled emotions into helpful mental reframings, and so recalling tough feelings and experiences that can't be cognitively restructured with diary methods might even cause more suffering.

While such research points out the possible advantages and disadvantages of audio diaries for diarists, others point out their potential uses for researchers. Audio diaries give an enormous range of control to the diarist since the researcher is not present when recordings are made, meaning the researcher has a minimized effect on how the data is actually collected. This is advantageous for the researcher, Monrouxe argues, because it allows for private and even sensitive information to be accessed which the diarist might not feel up for sharing if she/he were not fully in control. Or it might be practically impossible to record with another person present (2009). At the same time, this minimal control that a researcher has on how the data is recorded can also be a big problem, causing the quality of the data captured to suffer in several ways. For example, the diarist could veer off-topic in their recordings by ignoring the researcher's questions and just following their own interests, or they could involve others in their recordings that the producer didn't agree to or in a way that doesn't follow ethical research conduct guidelines. Furthermore, an important thing for split role researchers who are also media practitioners to consider is that the technical quality of the recordings could become massively unstable if the diarist is solely responsible to record themselves, resulting in diaries that may not be good enough to use for professional broadcast.

When compared with written diary methods, audio diaries have been defended as favourable because diarists sometimes find them easier to complete. That is, less energy and time is required for speaking as compared with structured writing due to diarists' fluency with talking fluidly in a stream of

consciousness (Markham and Couldry 2007). In other words, recording diaries as audio files rather than writing passages can make the whole process a bit more straightforward and less demanding for diarists. But while recording processes can be made more straightforward, this is not to say that audio diaries are necessarily easy to complete. Mazetti and Blenkinsopp argue that there are high levels of attrition when using diary methods because of the high demand they put on participants to regularly record themselves. They point out that "studies tend to show an inverse relationship between intensity of data gathering (frequency and duration) and sample size and participant retention" (2012). This counts for a wide variety of structured, semi-structured and unstructured diary methods, not just audio diaries, but remains relevant for discussions about the limitations of audio diary methods in particular.

Conceptual relevance of audio diaries for this research

As I have explained, I have been looking to design an emergent engagement experience for communicating experts and publics about synthetic biology. Once designed and produced, my aim is study how communicative experts as well as the engagement event's producer experience emotions and affects along the way and what that does to affect their participation. With respect to synthetic biology, the first voices publics usually hear from about matters of concern tend to be scientific voices (in the news, quoted in articles, in documentaries, live at museum events, at science fairs, etc.) When there is a hegemonic group (in this case, scientists) speaking for synthetic biology, publics may hear only their point of view even though there is also a diversity of other kinds of experts working in the area with additional perspectives to offer. As Bakhtin argues, a unified discourse spoken from a single position is not a reflection of reality, because it neglects the heteroglossic forces that complicate that discourse for its own convenience. I would like to enable more polyphony – created through heteroglossic forces - in the avenues through which people take in and contribute to the public discourse on synthetic biology. The diary method helps me do

this because it allows me to collect the thoughts and feelings from several different diarists at once and asks diarists to think about synthetic biology over time rather than have an answer, opinion or argument ready for immediate response. The diaries, recorded slowly over many weeks, offer access into their thinking processes as they develop, as opposed to the call and answer format of a live interview. This slow process allows more time for multiple points of view to emerge.

With this project, I wanted to create space for polyphonic engagement about synthetic biology in a Bakhtinian sense by highlighting the field's multidisciplinary voices, with their unique personalities, feelings, opinions, and attitudes about the field. I then wanted to open that polyphony up to wider publics so that affective engagement about synthetic biology may further unfold. In order to do this, I put importance on the possibilities for affect bound up in the human voice that I have learned from my radio practice, and take inspiration from Joe Richman's radio diary methods as a tool for gathering polyphonic voices - which may or may not transmit affect bound up in personal stories on to other listeners - over time. Therefore, I have combined audio diary methods from the social sciences with public radio techniques to explore what the use of audio diaries in science communication can do to open up the heteroglossic functions of public engagement about science.

An important aspect of this research is to see how the use of audio diaries can extend heteroglossic approaches to science communication. It does that here by collecting, displaying, and making interactive the recordings of several different disciplinary experts' feelings and thoughts about synthetic biology. To that end, I equipped diarists with a relatively unobtrusive technological device to record themselves with which could fit in a purse or a backpack. I then proceeded to send them an open-ended question once a week for twelve weeks that asked them to reflect on a particular matter of concern that related to synthetic biology. Moving through their own spaces, on their own schedule, with full agency to decide where, when and what they recorded, the diarists were able to express their ideas and feelings in

whatever ways they wanted to on file. And as a small but growing amount of social science research on audio diary methods demonstrates, without the audio diary's unobtrusive quality, the room to speak as freely and intimately as they did might not have been possible.

Choosing the communicating experts who would become diarists

In order to create a polyphony of multiple voices, I needed to assemble a group of communicating experts who possessed those voices and could knowledgeably respond to my prompts about synthetic biology. These would be the same people whose participation I would later analyse from data collected during Aurator's production process as well. I spent a great deal of time thinking about who I would like to invite to participate. The most important criterion for selection was that I assemble a group that could come sufficiently close to representing a large part of the diversity of disciplines that are involved in creating, analyzing, monitoring, regulating, innovating, critiquing, imagining and commenting on synthetic biology today, in order to try and represent the polyphonic quality of the voices that are connected to the field. This meant that I needed to reach out to potential participants from the natural sciences, social sciences, humanities, art, design, civil society, law, governance and biohacking scene because, as I have explained in chapter two and elsewhere, these disciplines mainly constitute the multidisciplinary actors involved with synthetic biology today (Wray 2015). I tried to do this by scanning through my scholarly, professional and personal networks for relevantly aligned individuals. I hoped to assemble a group of ten, because I was given permission from my department that I could send ten university-owned audio recorders out to research participants for this study.

I tried to keep the genders balanced in my first round of invitations, which I was happy to have achieved when I initially reached out to 9 women and 10 men (assuming that at least half would decline). Unfortunately, it was not a gender balance that I was able to retain in the final participant group. I

selected potential participants from across the disciplines who are active in synthetic biology and could be said to have at least a few years of publicly recognizable involvement with it. In other words, people who are generally interested enough in their work to take advantage of the opportunities that come their way to communicate publicly about it. These were people whose careers I have followed at some point or another since I first started researching synthetic biology in 2009. Between social media, academic research, pop-science events, festivals, and meeting people at conferences over the years, I had a good understanding of who regularly engaged publics about their synthetic biology-related work. But final choices about who to invite were made less by how familiar I was with their work, or their experience with public engagement, and more by who was willing and how well balanced the representation of various disciplines was when they came together as a whole group of diarists.

Luckily, ten of the people I reached out to wanted to learn more about the project. And to my surprise, after learning more, they all agreed to participate despite their busy schedules, which they often said was because they were interested in the method being employed. Each person who agreed to participate filled out and signed a project consent form (available in **Appendix A** of this thesis). I outlined in the form that I might one day use these recordings for a professional audio documentary project that would be heard by public audiences, which I realize might have also helped convince some of these people to participate. To those who agreed, I am very grateful. In the end, I was able to confirm the following diarists (named by discipline only): Two synthetic biologists, one entrepreneur, one biohacker, one artist, one watchdog, one social scientist, one governance scholar, one bioethicist and one university communications officer. Of these, six were men and four were women. Along the way however, two women and one man would drop out.

Once my group of 10 was assembled, on February 6th, 2015, I asked the diarists to watch an instructional video I had made for them about how to use their audio recorders properly, which I had put

on Youtube. The video can be viewed online at https://www.youtube.com/watch?v=CnL9VFB7OTM. The main purpose of making this video was to instruct them on how to capture high quality sound with the recorders, such that the quality would be of a professional standard. My intention was to ensure that audio quality would be high to keep open the possibility for a public radio documentary or interactive audio production.

Pre-project interviews

Before we began the weekly audio diary recording process, I conducted an interview that was approximately one hour long with each of the ten participants. In the cases where I interviewed those who live in Copenhagen, I visited them in their offices and simply took notes as we talked. In cases where we could not meet in person, I interviewed them on Skype and used the software Piezo to record our conversations. I then sent these interviews to get transcribed by an online transcription service.

Generally, in these pre-project interviews I wanted to understand general background information about their life and work, and their experiences working in the field or interdisciplinary synthetic biology networks, as well as get a taste for some of the beliefs they hold about what issues they think synthetic biology raises. I did this in order to pre-emptively collect information about the diarists that may not be revealed in their audio diaries, depending on how they would end up deciding to record them. Eventually I would need some way of triangulating the data between their diary contents and what I knew about their work already in order analyze what shaped their participation, which these interviews allowed me to do. I also planned to conduct interviews at the end of the audio diary making process as well in order to understand how they felt about the method as a way to communicate about science. By having pre-project interviews to compare the final round of interviews with, I would be able to glean more information about how the method did or did not change their views on public engagement and

participation. Therefore, taken together, my interest in triangulating data about their personal experiences in synthetic biology, and desire to leave possibilities for comparative interview analysis open, justified the need to conduct pre-project interviews. The questions I asked during those interviews followed this general sequence:

1. Can you tell me a bit about your background and how you have come to work with synthetic biology?
2. What type of interdisciplinary collaborations or research networks have you been a part of concerning synthetic biology, if any?
3. When working with others around topics related to synthetic biology, do you notice that you feel greater shared understanding with certain types of people and less with others? If so, who are those people? Why?
4. What do you find most interesting or fascinating about synthetic biology and how it is developing (scientifically, socially, etc.)?
5. Is there anything concerning you think people should be paying more attention to or thinking more about when it comes to synthetic biology?
6. Why did you agree to my request for your participation in this experiment?
7. Is there anything you hope to get out of this experiment?
8. Is there anything I didn't ask you that you'd like to talk about?

As these pre-project interviews were being completed with the various participants, the recorders were making their way around the world in the mail to their respective homes and offices in Canada, the United States, Denmark, the United Kingdom and Australia. Once the recorders had all arrived and the first set of

interviews were completed, we were ready to being the diary making process, which started in the week of March 9th 2015.

Scheduling and soliciting the audio diaries

To ensure that I would capture enough content from the diarists for effective analysis and use in Aurator's production, I had them agree to make weekly audio recordings that responded to a prompt in the form of a recorded reflection. Each diarist received an audio prompt once a week made by me, where I spoke directly to them in an audio recording that would appear as a file in their email. In the prompts, I sometimes related a little bit about myself and always posed a question about synthetic biology that I invited them to reflect on in any way they chose.

At times, the prompt would ask them to go out into the world and do something particular, such as record a dinner conversation with a friend or a stroll through the market as they thought about that week's question. Dinner table conversation with family members where they try to explain what they do in their work to their relatives would be the kind of scene I was seeking, for example. I wanted them to record the sounds of their lives and the settings around them in addition to their thoughts and feelings. From a sound designer's perspective, I wanted them to record the sounds that their DNA synthesizers, typing in bioinformatic databases, whizzing cell vortexers, commuting to meetings, etc., to add texture to the final interactive media project.

I expected that the diarists might feel some stress, fear or anxiety about making their first recordings until they got used to the exercise. To make them more comfortable, I made sure that I used my own voice in the audio prompts that I sent them, allowing my own personality to come through my voice and all the intonations that it carries. By requesting each of their recordings through audio prompts that conveyed my own tone of voice, I hoped to get them accustomed to the intimacy of using a singular voice

that speaks directly to a listener and what affect that can have. This was done in an effort to make them feel comfortable recording themselves in their natural surroundings, so that they might allow their personality to flourish through their natural way of speaking without self-concern. I made it clear to them that their diary recordings didn't need to be long, just genuine. They could record hours at a time if they chose to, or as little as one minute of reflection.

It was understood that they might miss a week of recording every now and then, as I knew that these were all busy people balancing multiple priorities. It was important to me that I communicated this understanding to them, because I feared that they might drop out along the way if they thought that the program of participation was too overwhelming or demanding of their time. The participants were asked to upload their recordings into a shared Dropbox folder that I provided them with, which only I could access. They uploaded on a weekly or monthly basis, according to what they agreed to in the project consent form. Whenever their recordings appeared in the Dropbox folder, I would transcribe them in full and would only skip over areas where there were long periods of silence or moments of incoherent stammering.

Weekly audio prompts

Due to the highly individualized nature of the recording process for the diarists, and the fact that I was not going to be present to mediate or guide any of their recordings when they made them, I was faced with a serious challenge as a researcher: I had so little control over what direction their answers might go in! In the pre-project interviews and post-project interviews I would later conduct, I was at least interacting with them in real time and could re-direct the train of their thoughts through follow up questions if they strayed too far from what I was hoping for them to respond to. However, now the ball was totally in their court, and I would not be able to react to what they were saying until they sent me their

files. That posed some interesting constraints for how I went about making my prompts.

Since the prompts were designed to provoke a point of departure for their audio recordings, one element of control I did have was the prompt and what it asked them to do, which I sent them each week. The other element of control I had was to adapt future prompts based on what I had already heard in their recordings from previous weeks that they sent me. At times, I did slightly adapt my prompts based on what was revealed in their previous recordings, in addition to what new knowledge about synthetic biology was emerging in my research or in the news over the recording time period. Therefore, deciding upon the prompts was an ongoing constructive process shaped by what I was hearing in the diaries that came in, and what I was discovering in scholarly research and the news.

At times, this was a nerve-wracking challenge. When you have only a limited opportunity to ask questions of your research participants (in my case, twelve prompts over twelve weeks), you want to make sure that you design them correctly in order to optimize what you will be able to do with your analysis. You also don't want to waste people's time, or make them feel that they are part of a project that will not yield anything of value. In other words, the questions need to prompt reflections in themselves that they will find interesting enough to do and still feel hopeful about what it might be creating after they receive each week's prompt. Therefore, I had an interest both in privileging my future research outcomes and managing the judgments of my diarists. In my case, this was an experimental practice of balancing understanding, expectation and curiosity. An elaboration on the content of my prompts, the process of their creation and how they were responded to appears in my first analytical chapter. But generally, the prompts that I sent the diarists took the following form (as an audio file that they listened to on their personal device:)

Below is an example of one of the prompts that I sent to the diarists, in the second week of the diary collection phase. To see all twelve weekly prompts, please look in the appendices of this thesis.

WEEK TWO

Hello. This week I'm wondering if you could tell me about a time when you felt emotionally engaged with synthetic biology. So, what do I mean by that? A time when you felt moved by being exposed to some element of synthetic biology, some story about it, perhaps it was even the first time that you were lured into thinking about synthetic biology. If there was something potent that really triggered you to investigate it further… Maybe you saw a film that synthetic biology touches on, or had a meaningful conversation one day with a researcher who, you know, burst your mind open about a specific topic in synthetic biology that you did not know about before? Or maybe you went to an art exhibition, or a museum, or saw a demonstration in the streets somewhere. If so, what did it feel like when that happened to you? Can you paint me a picture of it? Don't just tell me about it, but show me what the world was like that day. I'm really interested to know about how emotions connect to experiences of exposure and learning about synthetic biology, so, if you could tell me a little about when you felt moved more than you often would when just reading a journal article about synthetic biology, or a newspaper article, something that really gripped you…What was it that gripped you? And what did it make you feel?

Post-Project Interviews

After the twelve weeks of sending prompts were over, I allowed for two months to pass before conducting the post-project interviews with each diarist. Some diarists needed the extra time to finish their recordings, and so I wanted to grant them that flexibility before asking them about how the process of making the audio diaries was for them. Once they were ready, I interviewed each of the remaining diarists (there was some attrition throughout the process, which will be discussed in my analytical chapters). Each interview lasted approximately forty-five minutes. I interviewed them at this stage in order to gather data that would help me understand how the diary process did or did not live up to their expectations, and did or did not affect the way that they think about synthetic biology and public engagement. This way, I could later analyse how this method functions as a tool for science

communication scholars and engagement practitioners interested in polyphonic possibilities for public engagement with science. The questions I asked each diarist follow:

1) Is the audio diary making process different from other kind of research or interviewing you've experienced before? How so?
2) Did enjoy this format as a way to think about synthetic biology? Why/why not?
3) Was it ever difficult to participate? If so, how/why?
4) Did the project take too much time? Or was it okay?
5) Who did you imagine you were talking to when you made your recordings?
6) Did you develop any habits for how you responded? For example, did you do them every week or did you do binge responses every couple of months? If so, did that have any effect on how you answered?
7) How did you understand my role in the project? And how did you feel about that?
8) Did you ever feel vulnerable in the exercise, either from the format or the questions? Professionally or perhaps in other aspects of your life? If so, how?
9) Did you discover any new things about how you think about synthetic biology by answering the prompts? What?
10) Did any of the prompts, or experiences you had answering them resonate in your life in any way? Did you find yourself thinking about them after the fact, or going over what you had said?

Once the audio diary process was completed, I had all of the materials I needed to move onto the media production part of this practice-based research as I embarked upon making my first audio-driven i-doc. In other words, the polyphony that was captured through the audio diaries is substantive of Aurator's production.

Challenges of practice-based research

Practice-based research first emerged in Australia in the mid 1980s when a variety of universities there started introducing doctorates in creative writing that allowed PhD students to produce their own creative writing in a process of reflexive research and "praxis" (Candy 2006, Scrivener and Chapman 2004). Others argue that the rise of arts-based therapies in the 1970's generated academic momentum for looking at what art can do to produce new knowledge, which has in turn affected practice-based research (Leavy 2015). Since then, practice-based research has started to garner its own funding sources from research councils in places like Australia, the UK and Canada,[17] however it largely remains at the boundaries of how knowledge is produced in mainstream scholarly practices. As such, some universities, including the University of Copenhagen where this dissertation is housed, lack formalized guidelines on how to evaluate practice-based PhDs, even though they may allow interested students to take a practice-based route to research, as my university did in my case. This lack of clear guidelines however puts students, supervisors and committees in an awkward position of having to judge what counts as adequately rigorous knowledge-production for a PhD via practice-based methods for themselves.

This challenge is laid atop an already fraught debate about the state of practice-based research. Basic questions, such as what kind of knowledge art or media practice produces, and through what modes it produces it, continue to be discussed - while not easily agreed upon - in scholarly discourse (e.g. Candy 2006, Candy and Edmonds 2012, Leavy 2015, Makala et al 2011, Tin 2013). Pakes points out the kinds of core questions practice-based research urges us to contend with: "Is new knowledge generated in the process of making, and then made manifest and shared through the verbal reflection on that process? Or do the artistic outcomes of that process – the artefacts created – have epistemological primacy

[17] My doctorate is partly supported by the Social Sciences and Research Council of Canada's funding stream for practice-based research.

as the embodiment of new insight?" (Pakes 2004). A third option is that the research and practice are equally substantive of each other in terms of the knowledge they produce, without one out-performing the other. In light of such questions, practice-based researchers must make considerations that go beyond what is normally required for PhDs, that is, they must consider both their methodology and their methodological rigour for convincingly dealing with these questions in such a way that the work they produce clearly warrants a PhD. As Scrivener and Chapman succinctly note, "This situation, which is a source of inspiration and anxiety for both supervisor and student, requires a level of critical engagement with the debate on the theory and practice of research not demanded of researchers in those disciplines where shared and agreed research principles and methods have become embedded." (2004). This is a considerable and challenging inescapable intellectual exercise that all practice-based researchers (and their evaluators) must bear the burden of.

These kinds of general epistemic challenges are well documented in theoretical writing about practice-based research (e.g. Candy 2006, Leavy 2015, Pakes 2004, Scrivener 2002, Scrivener and Chapman 2004), though they fall outside of the domain of relevant discussion to go into here. That said, my decision to do practice-based research in my PhD has introduced specific limitations to my study in terms of what I can learn – and make - with it, which I discuss in chapter six. Considering that I have to wear three hats at once in this practice-based research – as researcher, practitioner and research subject – I must balance three competing sets of interests as I carry out the work. At times these hats can be work simultaneously with relatively little friction, but there are instances where the competing agendas mean that I must neglect the needs of one in order to service another that is more important at a specific time for a specific reason. I preliminarily discuss these kinds of trade-offs in the section that immediately follows, and then pick up on them again in my analyses and discussion.

Limits of the practice-based research: selecting audio diaries for use in Aurator versus my analysis

As a practice-based researcher, I have two different agendas to try and satisfy when listening back to and editing the experts' recordings. The first is that I need to edit them in order to put them into the i-doc in a way that will add meaning and artfulness to the media project itself, while the other is that I need to analyse what they said in their diaries in order to answer my research questions. These are not necessarily going to line up all the time. For example, I may want to analyse what they are saying in a long passage of a diary because of how they are saying it (communicating intimacy, affect, emotion, etc.) but it could be too lengthy of a clip to be used in the i-doc. Another example might be that I select an excerpt to put into Aurator because it is witty and thought provoking, but it bears little relevance to my scholarly analysis, and so is left out of that process. There are therefore very clear selectivity tensions that arise when working with one data set for two different outcomes: a media project and an academic study. Sometimes they will overlap, but sometimes they will not. There will often be trade-offs between the two. The way I've tried to resolve this limitation of the method is to try to be as explicit as possible about how I make my selections for scholarly analysis along the way in this dissertation as well as describe my selections for Aurator if and where it is relevant to the scholarly discussion, but I must clearly delimit this written thesis here to make it clear that in my analysis, I am dealing principally with my scholarly research interests in the data set rather than the media producer's interests. It would be far beyond the bounds of this study to give the same amount of attention in the writing to every single editing choice that I made for Aurator's production. I even expanded on my production notes in **Appendix B** to make this hierarchy of attention and importance clear.

However, my focus on trying to answer scholarly questions with the same data set that was used to produce the final media project, inevitably shaped how Aurator was made. It is difficult to account for where these influences occur, as this is not a comparative study of practice-based research versus

straight science communication practice, and so it is not of interest to me here to run a parallel study where I simply make a public engagement project without also writing about it and along the way. Similar to the way Cohn (2008) discusses how the intimacy that gets produced between the researcher and researched in neuroscientific studies gets "extracted as artefactual noise" in order to make stable disciplinary claims, the way my selections of diaries for use in Aurator is influenced by my scholarly research questions (instead of just by my interests as a media producer) are also at times treated as "artefactual noise" in order to get the job done. This is because I do not have a method for qualifying exactly how that complex process of influence happens. It might be that my scholarly knowledge of synthetic biology discourse and its matters of concern cause me to select a diary to use on Aurator, but I can't know for certain that I wouldn't select it had I not been doing a PhD at the same time as making the media production. This murky ocean of scholarship's entwinement with practice is a significant issue that practice-based researchers face, and it is challenging to account for in precise terms. We may be able to explain how many instances of our practice shape our research and our research shapes our practice, but some aspects of their co-mingling feel nearly impossible to make explicit. Try as I do throughout this thesis, the lack of clear methodologies for this kind of practice-based reflexive analysis is a limit to my research. Despite these limitations, I continue to write about how my choices were influenced to the extent I am able below.

When curating diary excerpts for use on Aurator, I had to think carefully about how to not drown the user in a sea of data. I had tens of hours of audio recordings from my diarists that somehow needed to be parsed, categorized, and selected before their fate as becoming part of Aurator (or not) could be decided upon. I knew that putting all of the audio diaries on the platform in their full and unedited versions would be a mistake because it would produce an overflow of information without clear instructions about how a user should navigate them. This is a common problem that i-doc producers experience when working with copious amounts of media files and the interactive nature of the platforms

they use to tell stories. "These problems have to do with the apparent randomness of navigation, with the lack of perspective produced by the excess of millions of documentary video clips, the dominant temporal logic of online communication that tends towards the perpetually unedited present." (Dovey and Rose 2012: 12).

The audio diaries I was working with could be extremely long files at times (over an hour for a single diary), but human attention spans online are infamously short, and I therefore needed to cut them into manageable chunks that were worth listening to. But this was a difficult thing to define. How can one detect what is *worth* listening to? How can I possibly judge for others what would be worth listening to, for them? I can only judge this for myself. The recordings I find interesting and moving (read: affecting) could always be utterly boring to another person; there is no such inherent quality as "interesting." Rather, my values, experiences, biases and pre-existing knowledge shape my impressions of the communicating experts' diaries in ways that are likely not replicable for others, or at least not identically all the time.

To briefly repeat something I've already discussed, science communication scholars like John Adams have argued that subjects are not empty vessels into which information can be poured and then absorbed exactly as the communicator intends for it to be (2011). More realistically, receivers co-create the meaning of the information they get as it flows through their sense-making filters. Similarly, when I was listening to the diaries, the bits I picked out as interesting were only evident to me as such due to my own sense-making filters (such as my pre-existing knowledge of science communication theory, my knowledge of synthetic biology, my knowledge of these diarists, my tastes for particular kinds of humour and personality, my dislike of others, etc.) The researcher in me tried to make sure that I was aware of this deep-seeded subjectivity when working in my other simultaneous role as a practitioner who had to edit the diaries for media production purposes. While at the same time, the practitioner in me had to try and judge what would be affecting for others to hear amidst all of the available selections, despite the limits of the

method (as judging accurately for others is not possible) in addition to being responsible to the demands my scholarly interests were putting on the data.

When curating the diaries, the best I could do was try to select excerpts that had a clearly relevant message, closely tied to the question I had asked them about synthetic biology. This could at least establish a continuous thread of content in the audio archive that Aurator contains. However, I additionally tried to select diaries that I found particularly *affecting,* which meant I made the project vulnerable to other people's judgment and possible disinterest. Affect is interesting as it is tied to my research questions, while an obvious limit of this method is that not everyone else will necessarily see why.

Therefore, the friction grew here between my scholarly interests and ways of working as a practitioner. With the former, I have clearly defined research questions that I then use to design a study that can investigate them, but with the latter, the study the scholar designed must also function as my media practice, which might have different sensibilities, goals and measurements of success. One such eventual measure of success (beyond the purview of this thesis) would be how moved users are by their experience on Aurator. I also don't want to confuse users with particularly affective diaries when they think they're coming to a website to learn about synthetic biology – a subject that at first glimpse seems to have very little to do with emotion. If they aren't moved, intrigued or satisfied by the work that the scholar in me designed – and remember, I may only be moved by affective communication because of my particular knowledge of science communication discourse - then the media practitioner in me would fail. Although, by virtue of that failure, the scholar in me might be able to gather lots of interesting data about people's disinterest. There are always trade-offs when working between the split roles that are required with being a practice-based researcher. The juxtaposition of agendas and interests is hard to pull off. So then, is it worth it? I will explore that question in my discussion chapter.

I've always considered that a major challenge to this project is that it would be easy to make the entire Aurator experience very boring for a general user due to the academic and specialist nature of the material. While I cannot change the nature of the material, it is my challenge to make it artful, provocative, and capable of stirring new ideas in users' minds through the way it is presented. This is where my sensibilities as a media producer and journalist trained in the craft of audio production must take over to identify the parts of the recorded diaries that affect me (emotionally, intellectually), in the hope that it will similarly affect others. But as I already discussed, this approach is always subject to failure.

Sometimes while editing, the solution to this problem could be as simple as looking for a little bit of comic relief in the diary tape - finding parts that made me laugh, and that might make others who hear it laugh too. For example, I literally spit my water out and broke into laughter while listening to the Biohacker speak passionately about what he considers to be the over-hyping of synthetic biology by start-ups, when all of a sudden, he interrupts himself to complain with a dash disgust in his voice that his one-eyed cat is wiping its behind all over floor beside him. This unexpected comment immediately painted a picture in my mind of where he was and what was happening while he professed in earnest his concerns about synthetic biology. This discourse about synthetic biology was not being produced in a vacuum, it was being produced in a Biohacker's apartment in California where a one-eyed cat was dragging itself across the floor. That seemed kind of absurd. I enjoyed the laugh and being surprised by it. It made me feel that the Biohacker relatable because it reminded me that he has all sorts of other things on his mind other than synthetic biology, such as people and creatures he has to take care of, just as I do. He became a fuller person than "just" a Biohacker in that moment, and it made me want to listen to more of his diaries in case they were funny too. It was a helpful clip for forging connection and understanding his character. This is the sort of affective listening that I used again and again to make my choices about what to include in the final interactive audio project. In other words, *it affected me,* therefore I decided to include it in Aurator.

Making Aurator

Aurator is an interactive non-linear audio documentary archive for mobile and browser based platforms, which explores what individuals think, feel, and wonder about synthetic biology. Featuring personal audio diaries made by a diverse group of experts who work in the field - a former NASA bioengineer turned full-time biohacker, a synthetic biologist, the COO of a synthetic biology company, a bioethicist, an artist, a social scientist, and a civil society watchdog - users are invited to listen in on the private thoughts, feelings and experiences of individuals who are pushing the field in different directions. Aurator encourages users to question what they think about the social, legal, ethical and even artistic implications of this science. It also allows them to leave their own mark on the conversation by activating the microphone on their personal device so they can upload their own audio diaries to Aurator to evolve the discussion further. It is important to note that www.aurator.org is not fully functional on mobile platforms. The mobile site serves as a place where users can listen to the original communicating experts diaries, however they cannot respond to them or upload their own diaries there. To diaries and respond to the expert's diaries, users need to visit www.aurator.org on a web browser, ideally using Chrome. The reason why the mobile site is not fully functioning is due to cost constraints.

In order to follow through on this practice-based research beyond its theoretical inspirations to actually make Aurator, I needed to partner with other knowledgeable individuals, and so set out on a several month-long journey filled with multiple obstacles, failures and successes before anything was produced. A description of that work is important in order to account for a great deal of time and energy that was expended during my PhD research period, however it is not particularly relevant to the rest of this thesis, and in particular, the forthcoming analytical chapters. In the interest of being accountable to the decisions I made throughout Aurator's production process, I detail that process in **Appendix B**, where my description of making Aurator can be found. However, that description is not instrumental to my analyses

and following discussions. I would like to restate that the analytical chapters of this thesis are delimited to answer my two research questions about the function of emotion and affect in the production of science engagement projects, and that they do not explore how Aurator is actually used (or not) by publics, nor how the platform was technically made. Again, they do not explore how my production decisions relate to how publics take up their roles as participants on Aurator's platform, and my methodology subsequently reflects that. These sorts of questions may be studied at a future point in time, but for now it is beyond the scope of this research.

Ethics of working with media that is made of intimate data

Part of my role as a practice-based researcher in this study involves representing my diarists publicly by transferring the audio diary data they give me into media fragments that comprise Aurator. As a media producer and practice-based researcher profiling and remediating the intimate (privately recorded) audio diaries of communicating experts, I am inherently involved in a process of "telling about society" (Becker 2007). Synthetic biology is the part of society I am telling about, which I am not only representing through the polyphonic i-doc I produce with this research that is made up of real people's diaries. I am also asking users of the i-doc – members of the public who come across it – to tell me something about their thoughts on synthetic biology by the mode of engagement that is offered to them on Aurator. This highlights some ethical considerations that are principally grounded in an agreement between my diarists, the i-doc users, and me.

> "For every means of telling about society, there will be some group for whom that way is justified by a moral pact between makers and users, which specifies permissible ways of persuading users that what's alleged is valid and therefore can be publicly acknowledged as acceptable, and which identified sneaky and unacceptable ways." (Becker 2007: 134)

Becker argues that the moral pact, which recognizes that the participants' representation is acceptable - is not agreed to in "some self-conscious, document-signing way" (2007: 135). Instead, in these moral agreements, it is fair to suppose that people agree to it as long as they participate in the activity "even as one becomes aware of all these tacit understandings." (ibid). In this project, the agreement made by the communicating experts to participate did actually begin with document signing (a consent form) but no further document signing was sought in order to assess how happy or unhappy diarists were with their ongoing participation. Rather, I had to determine this myself by paying attention to where their co-operation to participate sustained itself and where their co-operation to participate broke down. This helped me assess the quality of their acceptance to how the diary solicitation process affected them and how I am representing them in the final media outcomes.

According to Becker, as I am "telling about society," I am entwined "in a game of expressing moral judgments, trying to avoid them, or making them in a disguised way." (2007: 141). Through the process of "telling about society" – which can take many diverse forms from mapmaking to filmmaking and beyond (though in my case happens through interactive documentary and writing in this thesis) – I inhabit the role of a storyteller that is saying something about the society as it is broadly connected to synthetic biology. This has moral valence because "storytellers almost always, implicitly or explicitly, take sides. Stories have heroes and villains, and the storyteller usually lets us know who is who, either by explicit labelling or by providing easily read clues." (2007: 143). I am, in my conscious attempts, trying to avoid making villains or heroes out of any of my diarists. However, I do recognize that in the process of representing my diarists through their diary excerpts that I pick to share on Aurator, I execute an element of control they do not have themselves. It is a form of power I have over them, which may impact how others come to perceive them, and therefore abiding by what is mutually acceptable is of paramount ethical importance.

As an editor, I choose selections from their audio diaries to use in Aurator that I find *the most affecting* in terms of how they affect me, bodily or emotionally as a listener (according to how I have already explained affect). However, the diarists do not necessarily understand that I am using this kind of selectivity in my production method. They do not know this partly because my research has evolved over time and such interests arose from a creative research process that was not fully clear when I started soliciting the diaries. I made it clear to my participants at the beginning that they would not be able to know in advance what the media product will end up being, because neither will I until it is done. Also, as a media producer, I do not craft media projects in a completely transparent process with subjects. As Becker points out, "which participants know all about the persuasive means makers use?" (2017: 136). My answer to this question would be none. This, of course, has ethical implications, because it means that I could abuse their trust in a variety of ways and use their likeness to craft narratives I credit to them that might fall out of the purview of what they intended to express. This is something I try to avoid doing at all costs in my production work. I attempt to act ethically and provide my diarists with the degree of care that is necessary, which Becker outlines when he describes the kind of agreements we enter into when we "tell about society" in acceptable ways.

The fact that my participants do not know all about the persuasive means I use to most effectively "tell about society" with their diaries is not strange or unique to this i-doc's production. For example, I never craft my radio productions transparently with my interviewees when I am making documentaries for broadcasters. Doing so is not part of the usual professional practice of documentary making. For starters, it would take far too much time to ensure that an interviewee is aware of each and every cut of tape from their interview that you are thinking of inserting into the documentary as you are editing. As a journalist and producer, I have great responsibility for how I represent my interviewees in the final media project. I always try and maintain their trust the entire way through by making sure that the way

I am editing retains the meaning of their words according to how they originally spoke them. I am also careful to not juxtapose them with other media fragments that would cause their words to take on new meaning. The entire editing process hinges on me making ethical choices about how I am caring for my diarists each step of the way. Therefore, I use Becker's notion of "telling about society" as a way to open up and consider the ethical choices I make in my creative production process, which I will account for in the analytical chapters of this thesis.

Theoretical framework for analysing what happened with the communicating experts

In this thesis, I analyse how emotions and affects shape how communicating experts take up, resist and transform their roles as participants in the engagement event I produced as the practice-based part of this thesis (Aurator). In other words, I investigate material conditions that construct experts' participation in engagement events, particularly through the lens of affect and emotion. In I do this by using Felt and Fochler (2010)'s concept of "machineries for making publics" and adapting it to focus on expert participants rather than publics. To refresh the reader of their concept, written about in chapter one and briefly in chapter two - "machineries for making publics" - are the processes by which publics come to inhabit their roles as participants in engagement events. Felt and Fochler argue that this can be understood by using Akrich's 1992 study of how designers imagine and frame how a designed object will be used. When coming up with the idea for an object, Akrich shows how designers "inscribe" their vision of the world in the physical design of the object. This vision may come in the form of value judgments, prejudices, desires, assumptions, motivations, and more for how that object should be used (Akrich 1992). Once the object is "inscribed", certain forms of its use inherently become "prescribed," which some users may automatically accept and cooperate with, however other users may engage with the object in other, less complying ways that the designer did not imagine nor offer them in the object's design. For example,

users could engage with the object in a tactical way, working against the grain of the designer's vision for how it should be used, and therefore resist the designer's "prescription" for the object's use that was offered to them. This denial or resistance of the "inscribed script" of the object is what's called "de-scription." A "de-scribed" object is something that gets made when a user subverts the designer's offer for how the object should be used and thought of.

Applying this concept to the study of participating publics in engagement formats about science and technology, Felt and Fochler write, "Participants might have very different ideas about the technology, the world inscribed in it, and their attributed roles. They might struggle with, attempt to shift, or to even reject the script – hence describing the technology" (2010: 220). Therefore, they argue that performativity of participation events can only be understood when one considers both the design of the engagement event, and its real uptake by participants. Many observations can be made when one does this. For example, do the participants inhabit the roles for engagement they were offered by the producer of the event in the way that the producer intended the participants would inhabit them? Not likely. They might resist doing what the producer expects them to do, or designed for them to do, when they planned the event. Or participants might co-operate, but could also add new modes to their participation that were not foreseen by the producer. For example, they might participate more often than the role encourages, or with new actions that weren't discussed. There is a spectrum of participation that is worth noticing beyond the binary mode of "did/did not participate." So then, the question becomes, what can be learned from that spectrum? How does the design of an engagement event produce different kinds of participation for publics?

As I've explained, I use Felt and Fochler's "machineries for making publics" for my own analysis of what happened while I was producing Aurator, but not without making an important distinction in and adaption of their thinking. Where they focus on the actual uptake of participant roles by publics

with their theory, I use it here to analyse the actual uptake of participant roles by communicating experts long before any "members of the public" appear to engage with them through Aurator's platform. I specifically focus on how affects shape the way that the communicating experts take up or resist their roles as participants in Aurator's production. I pay attention to how affect shapes how they inhabit what I have designed for them to do, and how they also sometimes accept, change or subvert their own modes of participation, transforming the role that I offered them into something else. The data I use comes from my pre-project and post-project interviews, as well as the audio diaries that were made to be used in Aurator and analysed for my research.

It is important to flag for the reader that this concept of "machineries for making communicating experts," as I have borrowed and adapted it from Felt and Fochler's "machineries for making publics", was not the theoretical framework that I used to design Aurator. My use of Stengers' "experts, diplomats and idiots" for "slowing down" expert thinking as it connects to polyphony, heteroglossia and i-docs were my theoretical frameworks for the project's design. Rather, "machineries for communicating experts" is indeed the theoretical framework that I use to analyse what happened along the way as the communicating experts carried out their roles as participants in Aurator.

In this study, I'm not talking about a "script" as a technology the way Felt and Fochler do, or the way that Akrich does in the original text that inspired Felt and Fochler (Akrich 1992). However, I do consider the script as a focal element for my analysis – albeit a much more flexible and open-ended one than a technology - whereby I define the script as the role that an invitation to participate in making science communication offers. In other words, the script is the overall range of possibilities for engagement that a communicating expert has at their disposal. There is a script for participating that an engagement event producer offers, but it is open ended and full of emergent opportunities. It is a *role* that participants can inhabit or dismiss in different ways. The script that I offered to the communicating experts

involves principles such as: 1) an agreement to reflect on one's own thoughts about synthetic biology and communicate them in a public forum 2) a weekly recording schedule; 3) a commitment to doing the full twelve weeks of recording the study has outlined; 4) a commitment to respond to the specific prompts I send them rather than something else 5) an agreement to communicate with me as the engagement event producer throughout the study and to send me their recordings in the agreed upon manner, etc. Without these things, the science communication production process itself falls apart, and so it is interesting to analyse the ways in which the communicating experts agree to this script, add to it, reject it, or otherwise change the terms. It is not important to my research that I use the word script and consequently analyse what happened in my study with terms such as "de-scription", "inscription" or "prescription" as Felt and Fochler do. Rather, I want to point out my understanding of how the concept of a script – understood as a flexible role for participation - applies to my study in order to highlight the suitability of adapting "machineries for making publics" to my own research questions about the science engagement production process. I look at how each communicating expert dealt with the script of participation they were offered in order to come to conclusions about how affect and emotion cause participants to respond differently to their script at different times, when making "emergent" forms of science engagement. I also shift the analytical gaze upon myself to this same effect.

I am able to analyse how affect shapes the engagement process by looking at how it functions at two different levels. The first level of analysis relates to how the communicating experts say they are feeling, act in emotional ways, or otherwise somehow transmit affective intensities. They may talk directly about their emotions in their audio diaries, or in their interviews with me, or the transmission of their feelings may be less explicit and more implicit in the way they are saying something or choosing to behave (for example, if they're audibly irritated while saying something). In this case, there may or may not be a cognitive awareness of emotion at play, but affects, understood as intensities that make a difference,

may be felt. The second level of analysis relates to how I felt during the research process, at different points along the way, whether that was during interviews, while I was collecting audio diaries from the communicating experts or when I was working with my technical collaborators to produce Aurator. I draw on data from my production journal to understand my own affective experiences during different parts of the process. I analyse my findings with these two layers of analysis according to the following categories that emerged from the data: 1) factors that caused the communicating experts to accept the script of participation that I offered them and to add (inscribe) new modes of participation into their communication activities; and 2) factors that caused the communicating experts to reject, resist, or change their participation (de-scription), leading to its breakdown. However, as I mentioned, the terminologies of inscription and de-scription are not critically important to my analysis, and I instead refer to processes of accepting the script, adding to it, changing it, subverting it, resisting it, etc.

Rest of analysis

After I have analysed how emotion and affect influenced what happened during Aurator's production for the communicating experts and myself, I turn my attention more broadly to ask how a project like Aurator that includes audio diary and i-doc methods, benefit as well as limit public engagement practitioners. Aurator is a public engagement project that was purposely designed to allow for as much emotion and affect to flow forth from its communications about science as the experts participating in it would feel comfortable sharing on their own. Therefore, I explore what these methods for public engagement do as tools for science communicators. I observe what forms of engagement they afford as well as risks they open up in order to make a contribution to science communication practitioners and researchers who may be interested in exploring practice-based research. I do this by constructively analysing data I gathered from the two rounds of "pre-project" and "post-project" semi-structured

interviews I conducted with the diarists, in which I asked them about their perceived effects of the diary method in their thinking and work related to synthetic biology, and note emergent themes by pattern recognition and identification of where they discuss matters that are significant in debates in the discourse about synthetic biology as it has already been explained in chapter two. I also provide a personal account of what I think the diary method did for me as a science communicator with multiple roles (researcher/research subject/practitioner-producer), in terms of the affordances and limitations it provided me.

Therefore, there are several components of analysis and discussion in the remainder of the thesis. Firstly, I analyse: 1) what actually happened during Aurator's production, using the "machineries for making communicating experts" theoretical framework, and 2) what opportunities and risks intimate research methods such as audio diaries create for science communication practitioners. Then I discuss what I've learned about practice-based research, in terms of its affordances and limitations, and take stock of what I've discovered about the restraints of public engagement. Lastly, I make general conclusions from my analyses about the role of affect and emotion in science communication and new acknowledgements about the trade-offs tied up in public engagement work. I argue that this calls upon practitioners to develop ethical sensitivities and asymmetrical caring sensibilities when making science engagement projects.

Chapter 4: Analysis Part 1

In this first analytical chapter, I set out to answer my first research question through a constructive analysis of empirical data that comes from my pre-project interviews, post-project interviews, the communicating experts' audio diaries that were made for use in Aurator, and at times, my research process journal. To recap, my first research question is:

> How do the emotions and affects experienced by communicating experts in science communication productions that publics will eventually engage with, shape how they inhabit their roles as communicators?

I have made several findings that help me answer this question, which I analyse using the theoretical framework of "machineries for making communicating experts" as it was just explained at the end of my methodology chapter. This was made by transforming Felt and Fochler's "machineries for making publics" into a framework that can investigate the social and material instruments that construct experts' participation in an engagement project, particularly through the lens of affect and emotion.

Factors that caused the communicating experts to accept and add to the script

Emergent themes from the pre-interviews I conducted with the communicating experts demonstrate a diversity of factors that caused them to accept the script of participation that I invited them to partake in through the audio diary solicitation process. These include: curiosity about the novelty or "coolness" of the methods; perceived usefulness of the communication experience for the diarist's own work (such as learning new methods and research skillsets through exposure to my research methods); the ability for their participation to reinforce what the communicating expert is already busy doing with their work, such as promoting polyphony in a Bakhtinian sense in the discourse on synthetic biology; the

opportunity to act on one's self-identification as a science communicator (Baram-Tsabari and Lewenstein 2017); and the hope to become a "visible scientist" (Goodell 1977) who may *move* or *affect* others by communicating publicly about science.

I came to these findings by analysing my pre-project interviews with the communicating experts, perusing all of the sections where we discussed their reasons for agreeing to participate and noting emergent themes. I also analysed their audio diaries and "post-project" interviews to look for moments when they added new communication activities into their participation that I did not ask them for, nor offer them as part of their script for this project. From these findings, I specifically discovered that communicating experts may attach new meaning to their participation that was not originally offered to them in the script if they perceive their participation as an opportunity to act on their own pre-existing self-identification as a science communicator (Baram-Tsabari and Lewenstein 2017), which I will explain.

At first glance, these data appear to provide many insights about what the diarists "thought" about my offer to participate in a public engagement experiment. However, upon closer reading, it is clear that their explanations about why they accepted the script are infused with emotional and affective language that describe emotional and affective phenomena. For example, "I often *feel* that…", "it's *cool*" (implying a feeling for something interesting or intriguing), "it would just be *really cool*", "I *like* the challenge", "this field is *very close to my heart*" and "I would *love* to be involved." Their words go beyond plain descriptions of rationales as they tap into affective concepts that breed emotions, such as excitement and love. Communicating experts have to *feel* something in order to be affected enough to cause their uptake of participation. Therefore, a sense of duty to perform and partake in public engagement on its own may not be enough of a motivating factor to cause an expert to accept the script. On what basis do I make these claims? For instance, the bioethicist said,

> "I think it's useful to be able to take part in research like this. I also thought your methodology of using the recorders sounded really cool and something I'd like to have an experience of. And so, being involved as a participant also gives me the opportunity to learn about the methods that you're using in your study and how you're applying them to conduct you research."

The bioethicist mentions the usefulness of participating in my project to her own work, which is a theme that reappears in several diarists' explanations of what motivated their participation. It is particularly interesting that she described the method as "cool," which suggests that "coolness" might be enough to justify one's participation in a new methodological experiment on its own. The affect stirring inside the bioethicist could be, at least partially, located in her expectation of a "cool" experience, which caused her to agree to participate. Therefore, if communicating experts think your engagement method is cool, intriguing, or otherwise worthwhile on account of its novelty, they might just be curious enough to accept your script. It is also always possible that communicating experts simply feel to need to perform these qualities. This suggests to public engagement practitioners that thinking "outside the box" and being professionally courageous by using untraditional (perhaps even unheard of) engagement methods may work in their favour for their ability to garner interest and commitment.

The governance scholar said,

> "For me, this (project) is another place to get reflective. To be asked good questions is such a gift...I would love the opportunity to see some of your synthesis and learn more about your process and what you find interesting. You have a whole different skill set than I do which I would find fascinating to find out more about."

The governance scholar touched on the idea of the method's usefulness for her own thinking about synthetic biology. That it provides "another place to get reflective" implies that she is already being reflective about synthetic biology and welcoming of more opportunities to do so. She has an interest in being asked questions that provoke her to decide what she thinks about her field, and would be grateful for more ways to have that happen. Therefore, perhaps unsurprisingly, communicating experts may accept the

script for participation if they can see that it aligns with their pre-existing interests, and may expand their own public engagement or research skill-set.

The artist said,

> "You know, I'm an exhibitionist. I like to get my views out there to some extent – actually, I like the challenge, and both being challenged and challenging people in regard to some of those ideas. And obviously this field is very close to my heart and so I feel that there is a need for, I wouldn't say my voice, but a voice like mine to be part of it."

The artist explained his rationale for participating as being connected to his self-identification as an exhibitionist – an artist who uses his body, mind and created objects to open up societal debate about emerging biotechnologies in diverse engagement fora (galleries, festivals, conferences, media appearances, etc.). As an artist, he does this for a living, however when he does it as my research subject, he is not rewarded for his actions in any form of compensation or guaranteed admiration from an art-loving audience, though he gets to extend his voice into new spaces where he believes its presence is valuable to nurture a polyphony when speaking about synthetic biology. Therefore, his pre-existing interests and desires for scientific discourse to be polyphonic affected his participation. I knew that polyphonic engagement was something the artist valued from having analysed his work in the past. My analysis of his rationale suggests again that communicative experts may agree to a script if it provides them with another avenue to do what they were already busy doing.

In order to interpret why the two synthetic biologists agreed to participate, I must refer to my research journal because I did not conduct recorded "pre-project" interviews with these two communicating experts. They were the first research subjects I met with during my project, and my methodology was not yet streamlined enough to have known to do so. However, I recorded my thoughts about my encounter with them when I first invited them to participate in my research journal, which comprises useful data for analysis. The two synthetic biologists worked together as post-doctoral

researchers at the Centre for Synthetic Biology at my university. The following passage comes from my journal entry about our meeting. They have been anonymised as synthetic biologist 1 and synthetic biologist 2.

> "Synthetic biologist 2 was open, enthusiastic and interested in my audio diary project. Synthetic biologist 1 was more skeptical. He said, "It's not that exploring personal feelings towards my work would delegitimize my science, but…maybe it could be bad" revealing something about how he thinks about the relationship between professionalism and emotions. He made it clear through his body language and explanations that he believed sharing emotions as a scientist could negatively impact the way that others, specifically colleagues, would perceive him. This reminds me of the "Carl Sagan effect," which says that scientists who spend a great deal of time communicating their science must not be that good at doing science, and are judged adversely by their colleagues for being notably visible in science communication spheres. Synthetic biologist 1 said he would think about it, but Synthetic Biologist 2 quickly stepped in to convince Synthetic Biologist 1 to participate by saying "it doesn't need to be scandalous or overly emotional." I assured them both that my interest was about capturing real human thoughts and feelings from synthetic biology experts, not inventing emotions and affects that are not already there in the first place.
>
> Then the following week at the Responsible Research and Innovation conference that my supervisor Maja organized, Synthetic Biologist 1 came up to me looking far less concerned than the first time I'd met him. He was excited, even. He told me how he'd recently watched *Particle Fever*, a film that documents the working lives of a group of scientists searching for the Higgs Boson using the Large Hadron Collider at CERN, right up until the point when their highly uncertain experiment succeeds. He said that he was really affected by the film, and that he loved it. Then, with light in his eyes, he asked if I was going to do something like *Particle Fever* with my project, and if so, then he definitely wanted to be involved. Although I'm working in audio, not video, and was never planning on making the same sort of story as *Particle Fever* since that would require a steady linear narrative, which is impossible when one is tracking a diverse group's "streams of consciousness" about science, I felt encouraged by his interest in participating after watching *Particle Fever* - a film that highlights people and their emotions as much as the science itself."

Although synthetic biologist 1 was hesitant about my invitation at first, he became convinced to participate as a result of experiencing a *moving* and *affecting* film that had a very emotional plot about the high stakes for the scientist characters in the film. His being moved by the film – demonstrating the power of emotions and affect to make people feel something worthwhile about science - then moved him to accept the participation script in the hopes that he might be able to affect others as he was affected by Particle Fever.

The New Celebrity Scientists by Declan Fahy is a book that looks at how public scientific icons get made in the contemporary landscape of science communication. It's forerunner, Rae Goodell's *Visible*

Scientists (1977) is an early contribution towards understanding why and how some scientists become visible in the public eye. Goodell writes,

> "Today's scientists become visible primarily neither for discoveries, for popularizing, nor for leading the scientific community, but for activities in the tumultuous world of politics and controversy. Aggressively taking advantage of the new communications media, they seek to influence people and policy on science-related subjects - overpopulation, drugs, genetic engineering, nuclear power, pollution, genetics and IQ, food shortages, energy shortages, arms control." (1977: 6).

In line with Goodell's observations, *Particle Fever* is a film that makes a handful of scientists visible by concentrating on the political controversy that surrounded the financing, building and existence of the Large Hardron Collider at CERN and its search for the Higgs Boson – an intrepid quest full of manifold uncertainties and considerable societal debate. Many scientists' entire lifetimes worth of work could have been deemed worthless in an instant had they not found the particle with their experiment. This inherently dramatic narrative about the state of science and its surrounding controversies results in a film that documents the emotional rollercoasters many scientists had to grapple with as they approached their experimental judgment day. In other words, it makes for great "visible science" according to Goodell, which synthetic biologist 1 was *affected* by and so accepted my script based on his (personally biased) expectation that my project's effects might emulate what he had experienced when he watched the film. Therefore, being moved by examples of visible science may cause communicating experts to want to become visible scientists themselves.

The biohacker said,

> "Why did I agree to your request? I already do a lot of this stuff on my own, like, I write a blog and I, like, dictate a lot because I drive to work, so I figured that this would basically just be something similar or the same. I also have access to a lot, like, a lot of people... because I'm kind of this, like, PhD scientist with well-respected work, also really heavily involved in DIYBio, like, all the different camps and people who are trying to monetise stuff, the people who are trying to, you know, support the movement, and the guy in his garage who's working on something --- like, I interact with all these people, I have access to them all and I think, like, it would just be really cool to talk to them and interview them for this project. You know?"

The Biohacker gave a unique set of reasons for participating from any other diarist. His main attraction to the study was based on his own self-concept as a well-connected player in the synthetic biology field (as a trained PhD scientist, former synthetic biologist at NASA, and now full-time self-employed biohacker). He recognized that his diverse experiences in synthetic biology endow him with distinctive access to relevant players in the field whom he wanted to produce science communication with. His self-concept as a science communicator shines through in his description all on its own; I never asked him to take on the role of interviewing others in the field about synthetic biology. I did mention to the diarists that it would be nice to hear candid conversations about their work with their partner, or children, if they have any and should they feel comfortable, to understand how experts talk about synthetic biology in intimate environments. However, the biohacker was suggesting something altogether very different than that. He was imagining himself in the role of a roaming synthetic biology reporter, striking up conversations with a variety of people in the field who he has exceptional access to. This self-identification as a science communicator is something that Baram-Tsabari and Lewenstein describe as a strand of science communication learning (2017). They suggest that science communication educators may look for their students' self-identification as a science communicator when assessing whether learning about science communication has efficiently occurred.

They write,

> 'People only learn something when they realize that they *can* learn it, when they acquire an identity as a learner. For science communication, this concept can be understood as achieving an identity as a science communicator. Many scientists, for example, think of themselves as not very good communicators. But if they have successfully learned science communication, they will have learned that they have the ability to communicate. They will have included 'science communicator' in their own self-image. This can play out in multiple ways: willingness to participate in science communication activities, support for their students and colleagues who communicate, reaching out to network with other science communicators." (2017: 11).

According to Baram-Tsabari and Lewenstein's description, the biohacker demonstrates that he

has learned – at some point during his career in science - that he is a science communicator in addition to being a scientist. He readily agrees to communicate about science, as well as reach out to other scientists in his network. Additionally, he has appeared in science stories several times in major online publications such as The Verge, Vice, and The New York Times. He engages his own online following by participating in popular digital gatherings such as the Reddit "Ask Me Anything" forum as well as produces his own video blog series where he interviews guests who work in his field. He is a practicing, and self-identifying science communicator.

But since his extended science communication activities were not something that I asked him to bring into the context of his participation in my project, his desire to do so was an act of adding new meaning into the public engagement experiment, which I had not built into the design of the experiment myself. This means that his personal excitement about his unique position within the field and self-identification as a science communicator *affected* his reason to participate, and led him to imagine new forms of participation than I had not imagined nor designed for any of the communicating experts. Additionally, his affective state – of excitement and enjoyment at the thought of his ability to do something that other people could not likely do in the same way – motivated him to agree to this project, and even extend it beyond my intention for the script.

Interestingly, the majority of his recordings that he sent to me by the end of the diary solicitation period consisted only of monologues, where he was speaking into the recorder by himself. At the beginning however, this wasn't the case. For example, the first recording he ever sent me was a candid taping of a work meeting he had with some former scientist colleagues at NASA about Mars colonization and how synthetic biology may support that endeavor. His second audio diary was another candid recording of an experience he once had talking about synthetic biology over beers with two well-known figures in the California biohacking scene. He sent these recordings to me in addition to two weekly audio

diaries wherein he also responded directly to my weekly prompts. However, by the third week, he was only sending monologue responses to the prompts, and no longer capturing conversations with others in the world around him.

I am not sure why his interest to record with others ran out of steam. In the post-project interview, when I asked him about the recording process, and specifically inquired if it took too much time, he said, "I wouldn't say that it takes too much time, but I can imagine some people would understandably not be able to find the time every week. Yeah, I mean, it was fine for me." So, time was supposedly not the issue, however I neglected to ask him specifically why he stopped recording others (I forgot), but I nevertheless sensed that as early as one month into the diary solicitation period, he had developed a steady routine for making his diaries. Out of all of the diarists, he was the most consistent in sending audio diaries to me. He always uploaded them on time, and unlike others, never once made brief recordings as though he was trying to "cross it off the list" as a task. He really *gave himself over* to the recording process, and often sent me audio diaries that were at least an hour long of just him talking to himself. He would get carried away with his own streams of consciousness, and sometimes divulge very personal information. He would later tell me, in our post-project interview, that the act of making the diary recordings were "like seeing a therapist, except a therapist for science." I will revisit this in a moment, however it is worth mentioning how this highlights the way that communicating experts can develop unforeseen habits of participation (which in Akrich or Felt and Fochler's terms would be called "inscriptions"), such as how the biohacker came to understand his involvement as a form of personal therapy instead of more normative professional science communication. It also highlights how communicating experts can fall out of habits that they originally devised themselves as (unnecessary but interesting) additions for their own participation, such as when the biohacker stopped recording his diaries of conversations with other prominent people in synthetic biology, even though his access to major players in the field was one of his main motivations for

participating. Therefore, even after self-willingly adding new modes of participation to the script, communicating experts may end up reverting to the most basic design of the script if it proves to work better for them.

However, it is not accurate to say that the biohacker's participation was a total reversion to "basic script". When reflecting on the audio diary recording method during the post-project interview, he said,

> "I enjoyed it…it allows the interviewee to, to open up to like, it's like, 'wow I can talk about all my crazy ideas and somebody is actually going to listen to them!' Because I mean in the real world either A) nobody cares, or B) nobody understands, or C) nobody has the time, so it is nice…It did not feel like an interview or a diary to me. For me a diary would be like, that's a way to output my deepest darkest feelings and thoughts that hopefully nobody would ever read. Whereas this was similar but the opposite where you know, it is kind of like seeing a therapist, except a therapist for science. Your therapist is like 'now I want you to tell me, have you had any crazy ideas lately, or any interesting thoughts you want to discuss?' And you're like 'yes, why yes, I have. Let me tell you all about them.'"

The Biohacker explains that the research process allowed him to share ideas - wild, meandering and farfetched ideas - through soliloquies that are not often readily listened by others to and therefore not divulged in normative settings. Here he knew that no matter what he recorded, there would be at least one person in the world who would listen and who would care about what he had to say, which brought a comforting sense that he enjoyed, which in turn helped motivate him to keep participating. He also explained that the process did not feel like a diary since he wouldn't ever make a genuine diary's contents publically available, but instead, to him, it felt like therapy. I became his "science therapist" who would listen no matter where his thoughts would wander. Therefore, from our interactions (where I was the split researcher/practitioner and he was the subject) emerged a relationship dynamic that was built on a type of care expressed through my commitment to listening. That feeling of being cared for by a "science therapist" created a safe space that he otherwise did not feel he had access to. It gave him a venue to

communicate "crazy ideas" that he may have normally kept bottled in. It made him feel he could be creative and experimental with what he said.

The discussion of "science therapy" through the audio diary solicitation process indirectly connects to what others have written about audio diary methods. As I mentioned in my methodology, Crozier and Cassell argue that verbalizing personal stories in audio dairies can allow diarists to reduce their stress levels and anxiety around certain things that may have happened to them. They call this process "cognitive restructuring" (2016: 402). Audio diaries therefore can be used as a therapeutic medium to make sense of one's life, reconcile difficult emotions, and make life a bit easier to bear.

With this finding, I suggest that public engagement practitioners should consider an ethics of care in their design of science communication projects, particularly when working with the "emergent model" of science communication as a theoretical frame for engagement design (Horst and Michael 2011). Explicit forms of planned care – that are designed into the engagement experience - may be something that will allow for beneficial phenomena to emerge from interactions with communicating experts. However, it is not possible to know what intentional forms of care will cultivate in the relationship between public engagement event practitioner and communicating experts. Sometimes the relationship needs to demonstrate what kinds of care are needed to enable certain effects through the emergence of the event itself, which is what happened between the biohacker and myself. I could not have predicted how he would have perceived my commitment to listening to him, but the care it engendered turned out to be a benefit to us both (the feeling of safety and being warranted for him, and "intimate" audio content for me to analyse).

The biohacker also claimed that the space the diary method created for him to think freely out loud about science fed back into his work in productive ways. A passage from our post-project interview explores how:

Wray: *"When you say you think about the diaries as science therapy, there's a reason people go to therapy. Now I know you didn't have a reason to seek this out as therapy since I approached you, but did it have any benefit for you, the way that therapy can have benefits?"*

Biohacker: "Well sure, especially delving into more theoretical or imaginative thought patterns has pushed me to explore that stuff even more. Especially in my science and my art. And it is something that I have, you know, have really started to try to take advantage of."

Wray: *"Can you draw a line between things you've done recently in your work and the audio recording process? Work that the diary recording process catalyzed for you to do?*

Biohacker: "Yeah totally."

Wray: *"Like what?"*

Biohacker: "Uh so a couple things. So, before we started the audio documentary diary, I mean, I did stuff like the chromocord[18] so it wasn't that I haven't really explored stuff leading to anything imaginative or futuristic, or done art and science or whatever you want to call it. But I just hadn't thought of it before as a genre for my work. I remember once you asked me to describe the future, where people use gene engineering, what that would be like and explaining stuff for the audio diary, and when I was recording I really started to create this world in my mind, right? This like, it became a genre, a world to me that existed, that could be developed into something. So then, I wrote a paper on genetic encryption, which is kind of futuristic and far out. I started working on making this at-home DIY CRISPR system too. I also wrote a grant about whole body microbiome transplants to obfuscate your microbiome and I made what I thought was a really interesting video about somebody from the future who is being chased down by the government because he engineers his cells. He is like a mutant, and engineers his microbiome in a world where genetic engineering of humans is outlawed, you know! Yeah so, I really, really started to get way more into exploring these futuristic science and speculative science works and uh, really create more of a world around it."

Wray: *"So these audio diary recordings were priming the pump for that work to come out of you?"*

Biohacker: "Yeah totally."

Wray: *"You weren't doing that kind of work before the recordings began?"*

Biohacker: "No I wasn't. The recordings like I said, allowed me to explore those ideas more

[18] The chromocord is a musical instrument that the biohacker invented which uses proteins to trigger the playing of electronic musical notes.

without fear of being criticized."

The Biohacker directly attributes the diary method as the origin point for three novel projects of his. Not only that, but the "at home CRISPR system" he mentions became a world-renowned and highly controversial project in the biotech community - an experimental kit for the DIY "do-it-yourself" community that allows amateurs to carry out gene-editing experiments on bacterial or yeast cells with CRISPR. He ran a successful crowd funded campaign on Indie Gogo for the project that raised US $71 036. The funding allowed him to manufacture and distribute DIY CRISPR kits around the world to anyone who ordered one. Within one year, several hundred kits had been built and shipped to customers. By now, he tells me, several thousand have been bought.

At the time that the campaign took place in 2015 (and still now), there was a heated global debate about how to regulate the use of CRISPR in human cells. A Chinese research team published a paper in 2015 demonstrating that they had used non-viable human embryos and edited them with CRISPR, pointing to the ease of the method in human reproductive materials, which generated a lot of public concern. Science media outlets were publishing a flurry of material about the potential misuses of CRISPR amidst an uncertain regulatory landscape. Then, while the discourse was emerging around society's need to grapple with the quandary of how to regulate powerful new gene editing tools, the biohacker's DIY CRISPR kit was funded and announced shipment dates. Although the kit was not aimed at editing human embryos, it got wrapped up in the flurry of coverage around CRISPR's potential misuse. The narrative put forth asked if people should be concerned that we've created a world where it is not only professional scientists who can edit the DNA inside cells, but also amateurs who edit cells with CRISPR at home. Some headlines that speak to the tone of the media coverage about the DIY CRISPR kit include "Is Do-It-

Yourself CRISPR as Scary as it Sounds?"[19]; "Inside the Garage Labs of DIY Gene-Hackers Whose Hobby May Terrify You"[20]; "What Happens if Someone Uses this DIY Gene Hacking Kit to Make Mutant Bacteria?"[21] and "The Revolution Will Be Edited."[22] The kit shone a global spotlight on the biohacker's work, and the media interviewed him for months afterwards about its potential dangers. In this sense, the Biohacker says that he took the world that he had envisioned in his audio diaries - a world that he had freely dreamed about without fear of criticism, where people can engineer their own cells at home without being regulated by the authourities - and started to turn it into something real. Causality is impossible to determine here, but it is worth noticing his belief in it, which I will return to. Although the DIY CRISPR kits were designed to use bacteria and yeast, not human cells, they were the first kit to demonstrated the accessibility of CRISPR to amateurs, which could theoretically be adapted in the future to work with human cells.

Public fear about the kits has not subsided, and in 2017, the German government said that it would punish any science enthusiast caught doing genetic engineering outside of a licensed lab. If caught, they will face a €50 000 fine or up to three years in jail.[23] This directly targeted German users of the DIY CRISPR kits who planned to use them in non-licensed settings. Then, a short time later, the Bavarian authorities wrote the biohacker to say that they had found pathogenic bacteria (risk group 2) in one of his DIY CRISPR kits, including some bacteria that are multi-drug resistant and ESBL producing (meaning that they produce an enzyme that makes it impossible for antibiotics to kill the bacteria). They requested that

[19] https://www.statnews.com/2016/03/14/crispr-do-it-yourself/ Accessed October 28 2016.
[20] http://fusion.net/story/285454/diy-crispr-biohackers-garage-labs/ Accessed October 28 2016.
[21] http://motherboard.vice.com/read/what-happens-if-someone-uses-this-diy-gene-hacking-kit-to-make-mutant-bacteria Accessed October 28 2016.
[22] http://discovermagazine.com/2016/june/11-revolution-will-be-edited Accessed October 28 2016.
[23] "BVL - Fachmeldungen - Gentechnik Mit Biologiebaukästen: Einfach, Aber Möglicherweise Strafbar." 2017. Accessed May 9. http://www.bvl.bund.de/DE/06_Gentechnik/04_Fachmeldungen/2017/2017_01_25_DIY-Kits.html.

the biohacker hand over all of his German customer information, which he refused to do. He also denied the claims to pathogenicity of his kits. Given the ongoing crisis in growing antibiotic-immunity of pathogens, this accusation created a new controversy about the kits, which had already been controversial for their ability to put powerful gene editing tools into amateur (and possibly irresponsible) hands. To this day, the debate continues between the Bavarian authorities and the biohacker's supporters.

Was the audio diary method really so generative that it was responsible for the DIY CRISPR kit and all of the international debates about its regulation? By that I mean, had the biohacker never participated in the audio diary project, would these kits not exist? This I something I can't ever know. Although the biohacker contributes his origination of the idea for the kits to the time he spent dreaming about speculative science projects while recording audio diaries for my project, as a researcher, I cannot take this at face value, particularly because I can't understand everything else that was happening in his life at the time. Perhaps he could have dreamt the same idea up over drinks with a friend, or awoken one morning with the idea fully formed in his mind. The audio diaries could simply be the place where the idea emerged, which would have emerged anyway. But there is something to be said for the function of *safety and security* that the biohacker felt to be creative during the process of recording the audio diaries, which he claims resulted from knowing I would listen to his "crazy" ideas without judgment. The fact that he draws an explicit line between his audio diary experience and the generation of new ideas that led to projects like the DIY CRISPR kit, should signal to public engagement practitioners the enormous degree of unpredictable emergence and that may be possible from using intimate research methods such as audio diaries, particularly when designed and managed with an ethics of care.

Lastly, the watchdog's participation yielded many findings about why communicating experts may accept your "script" and "inscribe" new forms of participation into it. In the pre-project interview, he said,

> "I'm most interested in the way in which you're doing it … it's something that isn't just their set of performances. I often feel that when you do interviews with somebody, and it's a one-off interview, it becomes kind of a performance in which there's a number of conventions on how people should relate and things that people have to get over and agendas and all the rest of it. And, so, I'm interested in if you break up that performance into a different way of gathering the knowledge, whether you come up with different, kind of, knowledges. So, it's your technique that intrigues me."

It was not surprising to me that the watchdog expressed an interest in what I interpret as Bakhtin's heteroglossic force that leads to polyphony, which he used to explain why he accepted my script. Like the artist, he was attracted to my audio diary method as a way of making room for different voices with diverse interests in the discourse on synthetic biology. That he does not want to simply repeat "their set of performances" (the performances of synthetic biologists and their supporters) is telling.

As a watchdog, his job involves tracking the technologies and applications bound up in synthetic biology, and speaking up for how they may impact marginalized groups. His organization works with members of civil society to create and disseminate materials about how synthetic biology could affect farmers in the Global South, for example, whose economies and livelihoods could possibly be negatively impacted by market changes that result from the commercialization of synthetic biology. As a case in point, one example that his organization has worked a great deal on is the increased availability of synthetically derived vanillin, which could make the labour of vanilla-harvesting workers in Mexico, Madagascar and Indonesia obsolete. In the pre-project interview, he said of his organization, "We are regarded as the radicals in the room, I think, and, so, you know, we get license to say things because of that, but we also get totally marginalised because of that." Depending on where he finds himself speaking (for example, a scientific conference on synthetic biology), his attempts to engage with synthetic biologists may be seen as uninvited interruptions in the room, rather than welcomed comments for meaningful deliberation and debate. The watchdog is embedded in the business of producing polyphony for the discourse on synthetic

biology. This suggests, again, that if your engagement methods align with what communicating experts are already busy doing, they may accept the script.

One day during the diary solicitation period, the watchdog wrote me to say that he had uploaded several diaries at once, including voluntary soundscapes that he made and stories he captured while he was attending the World Social Forum in Tunis. I was thrilled to hear of these efforts to add new unpredictable forms of participation into the project and was excited to hear what he had been inspired to record. I listened through the five recordings he sent me that day, two of which corresponded directly with weekly prompts I had sent him, the rest of which were of his own creative visions, including a beautiful soundscape of the medina in Tunis, a story about a man who owned a perfume shop, and a poorly recorded talk he gave at the World Social Forum. While I was listening to these diaries, I was most moved by his recounting of having met the man who owned a perfume shop in Tunis.

> "We were walking around the medina here in Tunis with rain pouring down and torrents through the tiny little streets and we found ourselves passing a tiny little shop, and we walked into it and it was a perfume shop…And the guy who runs it, a small Berber man who is a perfumer, then spent a while showing us all the oils, many of which he made himself… and I immediately recognized that they were exactly the oils that we produce through synthetic biology. And it was sort of, a very stark reminder of a very particular kind of, not just livelihood, but cultural pride that lives around these essential oils, around these fragrances, that they come from somewhere, that they deeply mean something to, in this case, this indigenous Berber man …who said that his father is a perfumer, and that's where he learned it all from. It's that culture of essences of fragrances of oils …that's being swept away with synthetic biology, where in fact the same fragrances will now just become chemicals produced by engineered yeast in a laboratory."

The watchdog claimed that the man's family tradition was now under threat due to the rise of industrial synthetic biology that would replace perfumers like him, and by doing so demonstrated an awareness of the power of narrative and character development to get a message across and draw a listener in. Consequently, I became even more excited to hear what else he might record over the coming months. It felt as though he might produce a wealth of emergent diaries about daily encounters that would certainly

be fascinating to add to the polyphony on Aurator. I shouldn't have been excited though, because he would soon unofficially drop out of the recording regimen, much to my disappointment. And little did I know, it was because of something that I had said.

Factors that caused the communicating experts to resist, diminish or annul their participation

Unfortunately, there were many problems with the watchdog's recordings from a technical standpoint. These were problems that had made the audio quality suffer (handling noise, wind, extremely high levels of microphone sensitivity, etc.) but amidst those mishaps there was still some usable audio. I emailed the watchdog to let him know that I had loved his recordings and looked forward to hopefully hearing more, including unpredictable recordings that I hadn't prompted him to make. I also gently asked him to revisit the training video I had put on Youtube that explains how to handle the recorders in order to ensure the best sound quality. I thought it was a reasonable thing to ask, since I hoped to use a great deal of excerpts from his diaries on Aurator due to their dissensual character. As an off-site media producer, there was only so much I could do to safeguard sound quality, so I referred him to the training materials once more. But I should have kept quiet; I never again would receive an audio diary from him after I did that. I didn't even receive an email from him explaining why he was no longer participating, or updating me about his thoughts on the project. It wasn't until the audio diary solicitation process was completed, when I was conducting post-project interviews with each of the communicating experts that I learned what had gone wrong.

The watchdog told me,

> "So, I found it completely fascinating as an idea to begin with which is why I thought I would have a go, and probably I should have just said, 'you know what I don't have the time for this.' But I thought it was such a great idea that I thought I should step up to it. You had said, 'look it can be done when you're walking home,' so that flexibility was like alright it is fine I don't need to be too disciplined about it."

But then I asked him to re-watch the training video, and his perception of what participation meant completely changed.

> "I think particularly after I sent you the initial stuff and you said that the recording was not good enough quality, I clearly had to go back and re-watch your video and kind of relearn what I was supposed to do, and that then became a barrier. It went from, like, 'oh my goodness, I think I've got it and I can bring this thing everywhere with me and I can just whip it out and record stuff' to actually, like, 'no, it's really got to be a particular technical quality and I need to make sure I've really got it.' It was like, ugh, I haven't got the time to go back and listen to that and practice! And all of that kind of became a bit of a barrier as well… for a while I really was carrying the recorder around in my bag everywhere I went and then it just kept not happening…I was initially like 'this is a great empowering little tool', and then it was like 'oh no, I don't know what I'm doing.'"

Learning this was certainly one of the most disappointing moments in my research process. For some period of time, the watchdog had the recorder on his person "everywhere he went" and saw it as "a great empowering little tool," and yet, I only ever received one batch of diaries from him because *I* had made him *feel* that he was incompetent by requesting that he re-visit the training video. The watchdog also mentions being very busy from before the diary solicitation started, initially doubting he would have time to participate properly, but it is clear from his response that the strongest discouragement he felt came from my email. I bemoaned the wasted research opportunity caused by my ignorance and lack of care. But I also learned a great deal from this encounter. Indeed, the communication that took place aligns with Michael and Horst's "emergence model" of science communication, where I could not have predicted nor prescribed how he would react to my request of him that related to the overall public engagement goals. As a result of my trying to prescribe a particular form of engagement with the watchdog by asking him to re-watch the training video, record with more attention, etc., it introduced a gamut of new concerns and anxieties into my research process because I did not successfully make contact with him and learn what had happened for months thereafter. (I tried on many occasions, but he never wrote me back). That had me worried, generating a slew of negative affects within me that impacted how I viewed my own role as a

public engagement event producer, researcher, and manager of my research subjects. It made me feel that I was destructively engaging with my communicating experts rather than building something of value for them by having offered them a script for participation in this engagement project. I felt a mixture of shame and embarrassment about the nosedive that this part of the project took. Additionally, he said in our post-project interview:

> "One aspect of it in retrospect, you know, you said parts might be used for a documentary or something like that … it is one thing to just record something and send it to you because it is just an academic provocation. But when you tell me that it might get used in a documentary then it all of a sudden becomes more important."

What he is referring to here is that his performance became more important *to him* when he considered that his diaries would be heard by more than only me and my research group. This perception further affected his dropping out from participating, shutting down the ease with which he otherwise felt he could make quality recordings. I had assumed that the potential for the recordings to end up in a media project would have been an encouragement, if anything, to participate. After all, it was for synthetic biologist 1, who wanted to become a "visible scientist" (Goodell 1977). But that assumption was an example of me inscribing my own values and feelings about participation into my expectations of the communicating experts. The watchdog's comments made me realize that I was treating the communicating experts somewhat as a group rather than as a collective of diverse individuals with different values, beliefs, tastes, and preferences. Therefore, I would urge future researchers to exercise dynamic, iterative and reflexive communication with communicating experts at all times in order to try and understand their unique dispositions and needs. In other words, I would urge them to take *great care.*

Care – the sensibility that allowed the biohacker to feel safe and secure enough in my virtual presence as I became his "science therapist" to add a wealth of unpredictable recording for Aurator and his own external projects, was the same sensibility that broke down in my interactions with the watchdog, leading to his rejection of the script. Care is therefore not a stable quality that is inherently possessed by the

public engagement producer, that affects all communicating experts they work with in the same way (Mol et al. 2010). My findings show that the engagement event producer must exercise a meta-awareness of care when creating fora for science communication by caring for how care is being negotiated with each communicating expert at all times.

I would also urge science engagement producers to be *careful* when assessing whether or not a communicating expert actually identifies as *an expert who communicates publicly about science* or feels that they *can communicate publicly about science* (Baram-Tsabari and Lewenstein 2017). The personal feelings held by communicating experts about their ability to communicate science may be less developed than the engagement producer expects or assumes. The fragility of people's egos should be treated with care. For example, feedback that asks for personal improvements should be couched in sensitive terms, examples, and requests. Of course, this is also a personality-dependent consideration, but my unfortunate encounter with the watchdog highlights the need to consider these parameters for any communicating expert involved in a science communication project.

Another interesting site of resistance occurred with synthetic biologist 2 during the diary solicitation process after I had sent out a prompt asking the diarists what they think the limits of synthetic biology may be, if there are any. In his diary that responded to that prompt, he said that he was "provoked" by my question and took exception to the way I had asked it. He did not like that I was "assuming that synthetic biology has limitations" by asking that question. He defended the field's nascent state, and argued that my questioning of its limits at such an early stage was therefore invalid. He said he was worried that I may be encouraging people who heard my prompt to regard the field fearfully by asking that (synbiophobia-phobia). In this case, my question generated considerable feelings of defensiveness on behalf of a synthetic biologist who had invested his career into developing the field, which he did not want to see cast in a bad light.

From this, I learned that I could make a communicating expert feel attacked, while being completely oblivious about it. I felt anxious about making one of my own diarists feel "provoked" by my phrasing of a prompt. We were only three weeks into the diary solicitation process, and negative affects were already emerging from what I had considered to be a value-neutral academic question. This made me feel uneasy because although I wanted to study the emotions and affects of communicating experts, I wanted the affective landscape of the research environment to allow engagement to take place over time, so that there would be volumes of data to analyse. If communicating experts resisted the script or dropped out from participating so early in the process, I feared I'd have little to analyse in the end. I was quickly relieved when he sent two more diaries later that week, which were cordial in their tone. But I shouldn't have been, because he would soon after officially withdraw from my study altogether.

It turned out that synthetic Biologist 2 was offered a prestigious research position in California, and was moving across the Atlantic, which he said meant he could no longer make audio diaries for me. Considering that several of the other communicating experts were recording from locations across a variety of large bodies of water, he also could have theoretically continued to participate. Therefore, I cannot be sure that his decision to quit was not somehow shaped by being put off by my question and what he may have perceived as my bias about his field. Perhaps after our miscommunication, he was looking for an excuse to withdraw. This type of interpersonal misunderstanding and uncertainty about what is truly happening is something a project is vulnerable to when using intimate methods such as audio diaries. Intimate encounters between the researcher and researched, in other studies, may be normatively extracted as "artifactual noise" (Cohn 2008). But I hold onto them here as data in order to demonstrate how *affect* in science communication can ultimately shape engagement outcomes.

The artist also resisted the script of participation for much of the diary solicitation period. In our post-project interview, he explained that at the beginning he had had a fantasy about the project, and

sensed that it would be so much easier to just record his thoughts into a machine than to formulate them in well-constructed writing. But what he actually found out was that the recording process was quite difficult for him take up. It might have been laziness he said, though he was not quite sure. What he could describe with confidence was that he experienced an unpleasant sense of pressure to do the recordings, which became worse and worse as my prompts piled up week by week. Research on audio diaries supports the observation that the demand on participants to record can cause attrition (Bolger et al. 2003, Mazetti and Blenkinsopp 2012). In line with that argument, the artist felt that he could not find the time to record his weekly diaries, and soon the bad effects of procrastination set in, as well as the emotional toll that comes with feeling guilty and bad about procrastinating. The audio diaries therefore introduced a source of anxiety into his life; a wave of negative affect that would not subside every time he thought about the project until he somehow managed to participate.

During the diary solicitation period, I wrote the artist several times, eventually nearly professionally begging for any recordings he may have made to be sent. Then, near the end of the three-month diary collection period, I received *all* of his diaries in one fell swoop. The artist, who had been very busy running a university degree program in Australia, another in Finland and developing a third in the UK told me that he was finally able to make some recordings thanks to the help of his PhD student whom he had complained to about feeling guilty for not yet participating in my project. The PhD student became firm with him about needing to participate and baited the artist into recording his diaries over a shared bottle of whiskey that he would bring to the artist's home. The benefit for the PhD student was that it would be a way for him to get to know more about his professor by interviewing him with my prompts. This would be a benefit for the artist as well, who was far behind schedule, and wanted to catch up to relieve his own conscience and rid himself of the negative feelings. When listening, I could hear the clinking of ice cubes in glasses in their recordings. I tracked down and thanked the PhD student, for after a

long period of strong script resistance, the artist added a new form of participation into the script by agreeing to his student's idea.

Overall, the communicating experts experienced varying barriers to participation that led to resistance or rejection of the script that I had designed for them. While some found the entire process quite easy to keep up with, and at times even enjoyable, others found it so onerous, burdensome or technically demanding that they stopped participating altogether at some point, or never started recording in the first place. Both the communications professional and the governance scholar for example did not send even a single diary due to what they explained were pressing demands in their personal and professional lives. And synthetic biologist 2 dropped out three-weeks into the recording. That level of attrition - 3 out of 10 diarists - either not starting or officially dropping out seems high. But it gets even higher when one considers that I almost lost the artist as well, and would have if it were not for his PhD student being firm with him about participating and creating an easy environment for him to do it in. Additionally, while a diarist like the watchdog never officially dropped out, he fell silent near the beginning and left me guessing if I would ever hear from him again. Although the bioethicist sent more diaries than the watchdog, her recording habits progressed similarly to his throughout the solicitation period, and dramatically tapered off half way through without any explanation. She also never made herself available for a post-project interview so I could ask her what happened.

Considering that I began with the hope that I would receive 12 audio diaries from each of the 10 diarists by the end, totaling 120 diaries, the archive of diaries that I received - 69 diaries in all - means that I only reached 58% of my recording goal. There are high levels of attrition with this method, which the literature on audio diaries supports. Making audio diaries is not like answering a pre-defined questionnaire that only takes an allocated set of minutes to complete (even though these can have high levels of attrition as well), and in most cases, it is not an exploration of a familiar data collection process for

participants. It requires that participants both make time to participate, and in the case of my project, learn enough technical mastery of the hand-held audio recorder that their recordings sound good enough for public audiences to hear in a professional media project. While some diarists were able to rise to the challenge without any complaints, others felt battered and overburdened by these expectations, which was reflected in their pulling out from the project. Attrition may be caused by affects and emotions that emerge throughout the engagement event from both within and outside of the boundaries of the project (for example, things that happen with the engagement event's producer or non-related things that occur in daily life). Therefore, the emotional milieu engagement events unfold in place practical demands on practitioners to learn how to care for unpredictable emergences, particularly when using intimate research methods such as audio diaries.

Now that I have analysed a variety of factors that relate to how communicating experts accept a script, add new meaning to it, resist it or flat out reject it, I will turn my attention to two remaining phenomena that my findings show also affect how communicating experts make decisions about their participation. These are: perceived audience and duration.

The effect of perceived audience

On the topic of audience, all diarists except synthetic biologist 1 said that they imagined they were talking to me when they were making their recordings, and not a disembodied imaginary public audience (though in the case where the artist was being interviewed by his PhD student with my prompts, he felt that he was both speaking to me and the PhD student). Synthetic biologist 1 on the other hand said he always imagined he was addressing a large public audience in addition to me. This is not surprising since he was initially motivated to participate because of the potential for his recordings to end up in a media production that would attract large audiences to his science communication and make him a "visible

scientist" (Goodell 1977). This is evidenced by his motivation to participate coming from having been moved by the documentary *Particle Fever,* and in another conversation that we had, from his desire to make a science podcast with this project that "lots of people will listen to." Inherent in the idea of attracting a large audience are several notions: that one will be able to present facts, generate some kind of effect on people's thinking, as well as become a "visible scientist" (Goodell 1977). And in order to want to be a "visible scientist," one must regard themselves as worthy of making science visible. In other words, they must identify as a being a capable science communicator and as having learned at some point in their career that they possess these skills (Baram-Tsabari and Lewenstein 2017). Indeed, synthetic biologist 1 had just won a national Danish science communication competition that was broadcast on television across the country. His self-concept as a science communicator was growing.

It is difficult to make claims about what the communicating experts' various perceptions of their audience did to affect how they recorded their audio diaries, but my presence as a constant listener in their minds warrants some reflection. In their recordings, the diarists often interjected their sentences as they were talking with direct interpersonal addressing statements that were targeted at me such as "you know?" or "well you know how I'm always full of crazy ideas, Britt" (biohacker). Things also occurred on tape that demonstrated that they were thinking about what I had specifically asked them before, such as to keep the ambient noise in the room around them controlled. When the social scientist was chatting with her partner she repetitively asked him to stop squeaking his chair because I had once said it needed to be quiet, and in another recording she asks her niece Bella to "say 'bye bye' to Britt." As Worth has argued about audio diary methods, "This insider status needs careful attention…the status of the researcher, and the positioning of the audio diary as a solicited research product complicate the relationship of participant as audio diarist and researcher as listener." (2009: 13).

Deborah Martinson, whose work has shown that diarists often perform their written or

spoken diaries with a particular audience in mind argues, "diary writers, as autobiographical subjects, find themselves on 'multiple stages simultaneously', caught in an ideological double bind, as it were, to maintain modes of social and moral conformity as well as to speak out and assert themselves" (2003: 9). There is always a construction of personal experience at play when one constructs a diary that is supposed to encapsulate how they feel, think or relate to a particular idea based on who they are and how they have lived, which lends a dimension of creative control to the process of diary making. "The construction of personal experience as directed by the participant (as opposed to the researcher) can be viewed as a performance and, moreover, a creative endeavor in the form of a verbal monologue" (Crozier and Cassel 2006: 399). In the case of the communicating experts I was working with, it is clear that their perceived audience affected their participation in very different ways. When the watchdog thought about speaking to a wide public audience as opposed to a small group of academic researchers, he strongly resisted from the script. He did not personally desire performing for that larger imagined audience "in the form of a verbal monologue" as Crozier and Cassel describe. On the other hand, a performance for a large imagined audience is exactly what synthetic biologist 1 wanted to create, and that idea not only caused him to accept the script but it transformed his original hesitation around participating into excitement at the prospect that he might bolster his developing identity as a "visible scientist."

There is also the risk of communicating experts having developed well-defined expectations of who their audience will be, only to later be surprised by who is actually engaging with the products of their participation. For example, very soon after Aurator went live, I got an email from the social scientist asking me if I would be willing to remove a significant amount of her diaries from the site. In her request, she said that she was "surprised to see that I have far more recordings that anyone else." This was not true, but she did have nearly as many as the biohacker and she was consistently one of the most participatory experts in the project. She likely did not expect the high levels of attrition with this method, and when she

saw that her diaries outnumbered those of several other diarists, she came to be uncomfortable about how much she had participated – how obediently she had accepted and performed my script. Was she worried about how that level of keenness would appear to other people? I do not think that was not her foremost concern. She was more concerned about how colleagues of hers who are synthetic biologists would perceive her diaries should they ever find and listen to them.

She wrote in that email that she had some serious reservations about what she had said in her contributions. Seeing it all on a website made her realize that what felt very private at the time of recording actually was not private at all, even though she knew this day would come at some point when her recordings would be shared with people beyond just my academic research group. She expressed a wish to have been less critical and less frank, and expressed that if she were to do it all again she would have made her diary entries that way. The experience of finding her diaries on the web made her feel exposed and vulnerable to people who may judge her for how she said what she said about the field. It started generating all sorts of uncomfortable affects, which moved her to contact me and ask me to remove a significant amount of her diaries.

"Perhaps it's because I'm a social scientist myself that I'm over-sensitised about these types of things, or perhaps it's because, more than other actors in the field, I am two-faced (or three- or four-faced) in my interactions in synthetic biology," she said. The social scientist was explicitly worried that what she said in her diaries could prevent her from maintaining and gaining valuable fieldwork access in the future. She explained that she is often concerned about what synthetic biologists will think of her writing, let alone what they will think of audio diaries that she made at a time when the process of making them felt very private and intimate, even though she understood intellectually that they would eventually be shared in a public setting. This dissonance between what a communicating expert may understand intellectually about participating and what they may feel in more sensual terms (i.e. that they have privacy and safety to

be critical) is a serious risk of using intimate audio diary methods. It could put real-world things at stake for diarists, and even if those stakes are imagined by the communicative expert and not acted upon by those who have the power to revoke precious things from them, it could still introduce considerable anxieties into their life and daily work.

I did remove some of her recordings from Aurator, as requested. This highlights how strong resistance to a script can arise when a communicating original expert's expectations for how their participation will play out in future scenarios does not match what they perceive to be happening in reality. It is interesting that her sense of audience changed drastically from the moment I first offered her the script to long after her participation in the event's completion. When I first offered her the script, I did not yet know that Aurator would take the form that it eventually did, but I had notified the communicating experts that their diaries would be part of a public-facing media project that was intended either for broadcast or online distribution, in addition to possibly a site-specific exhibition or sound walk. Although she knew this, for the social scientist, there was something very affecting about the physical experience of seeing her diaries exposed on a publically accessible website. She always understood that this day might come, but the way that it actually occurred had enormous affects. It destructively affected her participation, making her concerned for her reputation amidst scientific colleagues because of the critical way she spoke in her diaries about their shared field.

As I've explained in prior chapters, this power imbalance between social scientists and synthetic biologists is well documented in the particular kinds of interdisciplinary networks that she is involved in (e.g. Rabinow and Bennett 2009, Balmer et al 2016). The personal stakes she describes are not only hypothetical and speculative but could bear relevance to her position in those networks. This points to the material dimensions of audience and how it can generate feelings and affects in public engagement projects. Specifically, audience operates in multiple states at once – it is both an imagined phenomenon

that is always present as a disembodied presence during the preparation of an engagement project, and is a material, physical phenomenon when real members of the audience show up to the engagement event (in this case, internet users who visit Aurator). Therefore, the multiple states of audience cause different emotions and affects for communicating experts that can change their acceptance, addition, resistance or rejection of a script in engagement projects.

Within my audio diary project, the communicating experts are aware that I am at least a dual-roll figure: a researcher who will analyze their audio diaries in order to make claims about them in this thesis, as well as an editor who controls how their words are transformed and represented in a public-facing media project that uses their audio diaries as media for Aurator. This fact, in combination with the performative aspects of making audio diaries based on one's conception of audience already discussed, makes "the very act of completing a diary a risk for the diarist and an analytical challenge for the reader" or listener (Worth 2009: 14). Importantly then, the public engagement event producer who works with audio diaries must listen critically to their subjects' diaries in order to not foolishly take for granted that bestowing one's participants with a device that allows them to record themselves intimately, privately, and autonomously, will necessarily produce an archive of fully authentically performed selves. They may be performing to accommodate a variety of imagined or real audiences; performances that differ one from the next according to the power relations between the various audiences and themselves, and that differ according to the expert's own self-identification as a science communicator.

The effect of duration

The amount of time that the engagement event took (which Felt and Fochler refer to as "temporalities" but I refer to here as duration (2010: 231)) affected the construction of communicating experts' participation on two levels. Firstly, they felt differently about what the lengthy recording process

meant for their ability to participate compared with other participatory methods of shorter duration, which could shape the content they recorded. Secondly, the time between the diary solicitation process and Aurator's production allowed for the feelings of some of the communicating experts about their own participation to change.

To illustrate the first point, several communicating experts reported that there was something about the expansive time they were given during the diary solicitation period, and the autonomy they were granted to decide when they would record their diaries, that made them feel freer to explore their own ideas than they would have otherwise felt. Similar to the biohacker's comments about seeing a "science therapist," there seems to be a sense of safety that comes with giving recording control over to communicating experts, without a tightly pressed deadline for how they should participate. For example, when speaking about the durational aspect of this method, the entrepreneur said,

> "It was nice to not be on the spot and have to just say something. I was actually able to think about the prompts and mull them over. If you are in an interview with somebody or on a call, you just talk about the first things that come to your mind, and so you can reflect your honest opinions but you can't really fully think it through. Whereas here there was less pressure, I could think about things a lot more than a half-baked off-the-cuff answer that you would give during a live interview… Sometimes I would listen to (the prompts) and think about them and then come back later to answer them. It would be the equivalent of if you were to ask me a question live in an interview, and then I were to just sit there thinking about it for several minutes in an awkward silence. So, the pressure of wanting to answer immediately, that was all gone, and my answers were more well thought through … maybe more logical."

The entrepreneur's reflection on what the method uniquely enabled him to do as an informant supports existing literature on audio diaries. Specifically, that some of their advantages are rooted in their unobtrusive quality, which allows data to be captured when the subject feels like it, without having to rely on retroactive accounts (as interviews or even "after the fact" scheduled diaries must), as well as accessing cognitive sense-making processes for subjects through acts of verbalization (Monrouxe 2009). The entrepreneur admits that he sometimes took the time he was permitted to stop recording and come back to

it when he didn't have a fully formed answer in the first attempt. This element of control, he believes, affected the quality of what he said by allowing him to form a well thought out answer, and explicitly connects to "sense-making processes" that Monrouxe describes. Though I would add that such "sense-making processes" happen not only through acts of verbalization as noted by Monrouxe, but also through the ability of the subject to pause the diary, think about it, and return to finish the recording when they've generated thoughts that they feel are more well developed. I suggest that producers of engagement events can benefit by making the script of participation flexible along durational lines, handing over control to communicating experts who may be able to accept those scripts and add unforeseen meaning into them as a result of the flexibility they're offered.

To elaborate on the second point, the durational timespan between when the communicating experts first engage in making their communications (for instance, recording diaries) and when those communications become public and open for others to engage with, can allow for all sorts of new personal feelings to emerge about their role as participants in the event. For example, once Aurator went live, the biohacker wrote me to say that although he was very impressed with the project and thought that the website was beautiful, seeing it and listening to it had made him very emotional. He told me that he cried twice while listening to his published diaries on Aurator. Given the explicitly emotional nature of what he was telling me, I interviewed him once more to understand what he had experienced when he first encountered his diaries in a public setting. This was not a standard set of interviews that I conducted with all of the communicating experts, just the biohacker due to the feedback I received from him. Relevant parts of our interview are excerpted in the following:

> *Wray: "You said you cried twice when you listened to your published diaries on Aurator. Can you tell me more about how you felt when you were listening to them?"*
>
> Biohacker: "It's not often that you can listen to your thoughts outside of your own head. In the diaries, I describe what seems like a lonely life and perhaps a lonely person. Really

moving and really sad. Someone who can't share their emotions and experiences with others because their (my) world is obtuse. I had this problem the other day when designing some plasmid DNA for a specialized case and I was looking for some feedback. I don't really know anyone who has designed plasmid DNA much less for this case so it feels lonely. People want to yell about a president maybe because then they have something to share and commiserate and talk about with each other. I want that also but have a hard assimilating."

Wray: "Did your reaction upon listening to your diaries make you want to change anything about what you had recorded or what you had let me share publicly?"

Biohacker: "When I listened, it made me cringe a little thinking about how people will react to it. Especially given that the diaries were done a year or two ago and stuff has changed since then. But I said it and that is me and I want to be me unabashedly. I get sometimes that we say stuff out of emotion and it might not be the "real" us but I accept myself including the cracks and ugliness and deficiencies…I don't want to be perfect and I know I am not. I want to be wrong sometimes and angry sometimes and hated sometimes. Though I might not enjoy it."

Wray: "Did it make you think that you would like to approach how you represent yourself publicly differently in the future?"

Biohacker: "Yes, I want to be more like I was in the recordings. Put myself out there more even though I think people might not understand or accept it."

The biohacker mentions in this interview that the diaries were made a long time ago, and that much has happened during that time that would perhaps cause him to say things differently now than he did before. The duration that has passed has had material affects for his participation, where experiencing his participation now is a somewhat painful experience, but he accepts that and unlike the social scientist, did not ask for any of his troubling or cringe-causing diaries (even ones in which he directly criticizes others in the field) to be removed from the site. On the contrary, he stands up for how he once felt, even if he would express himself differently now, and believes that on principle he should stand by what he once said. Another intriguing finding is that the biohacker points out how emotional he makes his own life sound in his recordings: "really moving and really sad", "lonely life", "lonely person". As I've mentioned before, the biohacker seemed to relate very openly to the recording process, divulging very personal information at times and sharing a very emotional worldview. His diaries were explicitly emotional in a way that no other

communicating experts' diaries were. This highlights an ethical dilemma of using intimate research methods when inviting communicating experts into an engagement setting. The expert may take exceptionally well to intimate methods and be very keen to accept the script or even extend it in new ways, but their high adoption rate of the intimate methods does not mean that they have reflected on what might be at stake for them in the future once the engagement event is public and they are no longer entranced by the private rhythms of engagement (for example: recording) after they have ended. They may feel surprised, concerned, embarrassed, vulnerable, or ashamed to discover what they once revealed, long after the fact.

It is fortunate for my goals as an engagement event producer that the biohacker feels it is important to keep diaries on Aurator that make him feel vulnerable in public, but I can well imagine that other communicating experts would not react that way, and like the social scientist, would request ways to limit or considerably downsize their participation. Therefore, I urge engagement event producers using intimate methods to develop a flexible working relationship to communicating experts that recognizes the need for mutually agreed upon ethical accommodation of their changing needs that may result from emergent emotions and affects throughout the duration of the engagement. Indeed, Felt and Fochler argue that "temporalities" (which I call duration) are material machineries that "make publics" by shaping how people organize as members of the public who engage with each other and scientists during an engagement event (2010). Similarly, my findings show that the durational aspects of engagement events are also "machineries that make communicating experts" and how they organize their own participation in engagement settings.

Chapter 5: Analysis Part 2

In this second analytical chapter, I set out to answer my second research question, which is:

> How do emotions and affects experienced by the public engagement practitioner (the producer of the engagement event) shape what gets produced in the engagement project?

The empirical data that forms my analysis comes from the audio diaries and journal entries I made about the diary solicitation process, diary-editing process for use in Aurator, and my experiences during the time over which funds for Aurator were being sought. These data allow me to come to some understanding of my own emotions and affective experiences during different parts of that process, and what they did to influence how Aurator was created by looking for places where I accepted the communicative experts' diaries and inscribed them into Aurator (by including them on the platform), as well as where I rejected the diaries for Aurator, and thereby removed them from the final engagement project. At the same time, my analysis cannot account for such decisions in totally precise, fully knowable terms because the way that Aurator's media fragments were collected and arranged, from the beginning of this study to its end, through dynamic relationships with communicating experts over different periods of time, produced an intractable network of influences via emergent real-world events, affects and objects. For "methodology is itself constitutive of its objects of study: method is part of what 'makes' the event of engagement or participation, and the ways in which the various participants emerge within such an event." (Michael 2015: 82).

In order to explore such complexities, I discuss three main findings that emerged from my analysis about how my own emotions and affects influenced the final engagement project: 1) instances

where I added diaries to Aurator were shaped by emotions and affects I experienced that were stirred up when the diaries (i) touched a nerve with their "frank speech" about synthetic biology, (ii) used "wonder" as a framing device for communication, (iii) took form as acutely critical comments relating to debates in the discourse on synthetic biology, or (iv) were playful and performative. Similarly, instances where I rejected diaries from being used in Aurator where shaped by affects I experienced when the diaries: (i) were poorly recorded from a technical standpoint, (ii) were full of meandering or off-topic thoughts, (iii) when diarists were not speaking with clear cadence, pointed description, strong opinions, fully-formed arguments, etc. and (iv) when the diaries were full of specialist jargon. There are two additional dimensions that I analyse about things that happened which caused the production to unfold in particular ways, they are 1) the pressure I felt after a while to *simply produce* the engagement event due to external demands for professional delivery shaped Aurator's outcomes, and 2) ethical responsibilities emerged throughout Aurator's production as part of a practice that I call *caring for science communication,* which were underpinned by emotions and affects that the communicating experts and myself co-constructed through our interactions.

It is important to note again that I do not offer a detailed analysis here of the technical production of Aurator, a time during which I worked with Helios Design Labs and Nadja Oertelt to produce the digital manifestation of Aurator. That process was influenced by far too many technical and practical factors to account for in this thesis, and does not explicitly pertain to my research questions about the function of emotion and affect in science communication. It is beyond the scope of this study, therefore I have left such analysis of Aurator's technical production out (though a description of how it was made can be found in **Appendix B**).

In the last chapter, I described a few instances where my own personal feelings emerged through interactions with my diarists. One example is when I felt anxious about having provoked one of

the synthetic biologists with the way that I framed my prompt about the limits of synthetic biology. Another example is when I felt disappointed about learning that I had turned the watchdog off of the engagement exercise by asking him to revisit training materials to improve his recording technique. However, these feelings did not affect the overall production of Aurator in terms of how I chose to use these communicating experts' recordings on the digital platform or not. Rather, they were data that allowed me to analyse what had happened, and consider the implications of, for example, now having less audio diaries for Aurator as a result of my interactions with these communicating experts. In contrast to those types of personal feelings, what I aim to analyse in this chapter are sites of personal emotion and affect that *made a change in* the way Aurator was assembled in terms of how they *influenced* what I decided would go into Aurator (as well as what would not) and therefore impacted the final public engagement project that this thesis is centred on.

To recap, my results reveal three main factors that determine what my affective position towards the communicating experts and the content of their audio diaries did to shape the outcomes of Aurator. They are: being moved to select diaries or not select diaries for Aurator while listening to them, feeling the pressure to produce, and the ethical constraints of intimate public engagement "events."

1A) Being moved to select diaries for Aurator while listening to them

In order to select which parts of the communicating experts' diaries to include in Aurator, I used my body as a register through which I could detect when something was emotionally engaging or moving based on how I felt and what it made me think about as I was listening them. It was a conscious production decision to include audio clips that moved me, but their ability to move me was not voluntary. Rather it was something that would happen or not, beyond my control, in an affecting fashion. This could include speech that conveyed an idea that intellectually intrigued me, surprised me, made me laugh, made

me feel sad, made me feel sympathetic, took me aback, made me cringe, and more. Overall, the requisite was that what I heard in the audio diaries had to generate a stirring sense of affect in me, in the way I have described affect theory in my methodology, in order for me to consider putting it in the pile of audio excerpts to be included (or "inscribed") in Aurator's production.

However, as I also explained in more depth in my methodology, using my own body as a vessel for affect is highly subjective and context dependent. My mood at a given time on a certain day, for example, could determine how I react to audio while analysing it. Plus, it runs a risk of assuming too much about how other people perceive things. Furthermore, my awareness of the discourse in the field could cause me to take special interest in a diary and *find it affecting*, while others who know less about the discourse might be bored by it. Therefore, there are considerable limitations to my method of using my own body as a vessel to register affect through.

Nevertheless, I decided to use this filter of affect when sorting through the diaries for several reasons. Firstly, I had to think seriously about how to not drown the user in a sea of data. I had tens and tens of hours of audio recordings from my diarists that somehow needed to be parsed, categorized, and selected before their fate as becoming part of Aurator (or not) could be determined. I knew that putting all of the audio diaries on the platform in their full and unedited versions would produce an overflow of information without clear instructions for how a user should experience them. This is a common problem that i-doc producers face when working with copious amounts of media files and the interactive nature of the platforms they choose to tell stories with. Dovey and Rose outline this particular issue, as "These problems have to do with the apparent randomness of navigation, with the lack of perspective produced by the excess of millions of documentary clips, the dominant temporal logic of online communication that tends towards the perpetually unedited present." (Dovey and Rose 2012: 12). Therefore, committing to a filter of content eradication that was directly tied to my research questions served two purposes: cutting

down on the media for Aurator (a necessary step) and mining the data for particularly relevant media that carries theoretical relevance to my investigation of emotion and affect (the action of being moved). Taking notice of what I noticed about the affective quality of the diaries was a helpful way to shave down the data.

Secondly, as I've explained, I've always considered a major challenge to this project being that it would be very easy to make the experience of exploring Aurator incredibly boring for a general user due to the academic and specialist nature of the material on synthetic biology - a field they may not know or care about. Therefore, it was my challenge to make it *interesting*. By that I mean any combination of: artful, provocative, surprising, relatable, capable of stirring new ideas in users' minds, etc. This is where my sensibilities as a media producer and journalist trained in the craft of audio production have to take over to identify the parts of the recorded diaries that move me (emotionally, intellectually), in the hope that it will similarly affect others. Although my thesis focuses on the audio diary solicitation process and emergent relations with communicative experts as the principal site for a public engagement event, the reality is that I am also producing a media project that will exist in the world long after this thesis is completed, which I hope will be explored by users that have no idea about its PhD thesis sub-text. Therefore, my job is to try and make Aurator a worthwhile online project for those users to stumble upon and spend some time investigating. Consequently, I made my editing decisions along affective and emotional lines in the hopes that the content would be as lively and interesting as possible for those users, rather than granular, dry, esoteric, or purely academic. This was an ongoing challenge, and I do not claim to have made Aurator exclusively full of only intriguing, surprising, emotionally affecting diary content. There were, of course, limitations to what I had to work with, which were out of my control because they were determined by what the communicating experts had said in their diaries. Instead, throughout the production process I tried my best to hone my ability as an editor to identify and extract the "best" parts of the diaries (in terms of their ability to *affect* or *move* me) for public engagement.

So how did I hone that ability? Sometimes the solution pertained to easy uptake. By that I mean factors that caused me to immediately accept an audio excerpt for Aurator, which could be as simple as being affected by a little bit of comic relief in the tape that made me laugh, and might make others laugh too (such as when the Biohacker talked about his one-eyed cat on a mission to scratch itself, which I already described). Another time, I was struck with delight while listening to a diary from the social scientist who engaged her 7-year-old niece, Bella, in a conversation about synthetic biology and then recorded it. In order to explain the concept to Bella, she told her that synthetic biology allows humans to make biological things do "neat stuff" for us that we like, and then asked Bella what she would like biological things to do for her. Bella had many imaginative ideas about what she would like synthetic biology to make, ranging from talking bunnies to flying horses. She was an adorable discussant and I laughed out loud several times while listening to their conversation. My laughter immediately signaled to me that it would be good to accept the diary and add it into Aurator. When I notice myself reacting with emotion (smiling while listening, feeling happy, laughing and responding with some form of exuberance) I decide that it is worthwhile audio to include, as it could possibly provoke similarly enjoyable responses in others. If a diary like this one elicited a response in me that caused me to engage emotionally with it, I would take a risk on it and add it to Aurator.

When editing, my challenge as a media producer is to isolate parts of the audio diaries that say something intriguing - or feel somehow meaningful - either because of the content or how the communicative expert saying it, in order to move future unknown listeners. The listeners in this case are Aurator's users, stretching forth in time and I cannot yet know who they are. But from my present position as Aurator's creator, it is important that those future users hear things that make them want to explore the site further, and hopefully engage by responding to the communicating experts' audio diaries with audio responses or making their own new audio or text diaries (both of which are functions that the site enables)

rather than immediately close down the site and move on to another part of the internet. Editing and diary curation is therefore a crucial determinant of whether or not users will go further in the user experience, which puts an enormous amount of responsibility on me to try and positively shape that user experience through my editing process.

I can provide several more instances of how this worked. However, I included nearly 100 excerpts from the communicating experts' audio diaries on Aurator, and due to that copious amount, I will not analyse each and every included audio diary excerpt here. Instead, I will attempt to provide a representative overview of the kinds of factors that caused me to accept a diary and thereby use it on Aurator (beyond humour alone). They are: touching a nerve with "frank speech", "wonder" as a framing device for communication, acutely critical comments, playfulness and performativity.

Firstly, in one of his diaries, the biohacker discusses how he feels extremely critical of people who oversell and overhype synthetic biology without any working example of their product concept. He talks about the scientists behind the infamous Glowing Plant Project[24] and laments a variety of companies that spun out of a biotechnology incubator called Indie.Bio.[25] But the biohacker says he doesn't "buy any of

[24] The Glowing Plant had completed a successful Kickstarter campaign in 2013 so that it could genetically engineer transgenic plants that "glow in the dark," which they marketed as a natural nightlight. Their campaign was so successful that they raised US $484 013, far surpassing the $65 000 they set out to collect. They promised to send their funders the genetically modified plant seeds by mail, which caused an enormous controversy, so much so that Kickstarter declared it would no longer allow people to fund bioengineering projects on their platform. Not only that, but the campaign promised a specific delivery date for their engineered seeds, and now, five years past that date they still have not been sent out. The Glowing Plant has been criticized for being extremely overdue on their delivery date and for underestimating the degree of scientific sophistication that the project required. Many people I've spoken with who backed it on Kickstarter have lost faith in the project.

[25] For full disclosure, I was a mentor to the teams that were part of the first cohort of the Indie.Bio program, which tends to attract young and emerging scientists who have a disruptive product idea that synthetic biology can produce, such as growing synthetic cannabinoids in yeast or brewing cow-free milk in engineered microbes. Sometimes the companies that come out of Indie.Bio companies have well-

those companies' 'spiel"' on their websites and thinks they are just peddling flashy concepts for synthetic biology applications without the proper science to back them up. "Ideas are worth shit, it's the execution of ideas that matter," he exclaimed. It upsets the biohacker to see scientists such as those behind an initiative like The Glowing Plant Project stand up in front of the world to claim they're selling something useful and real, but that thing is still only an idea. It doesn't only hurt the credibility of those who are working in synthetic biology start-ups, he says, but it hurts the credibility of all people in the synthetic biology community, including him. He believes that it damages their reputation in the eyes of investors and the public who become increasingly skeptical of synthetic biology as more promises are made but the products are not delivered.

I included this excerpt in the audio clips for Aurator because it touched a nerve, which I could register as the feeling of being surprised and taken aback with the ferocity of his emotion when I listened to it. He was getting specific and personal about real-world examples of current synthetic biology products that were causing wider debate about the field. The specificity of his claims could be described as slightly controversial, given that he was talking about visible people in the field who might hear what he had to say. That is what surprised me - he voiced an opinion I'd only before encountered in dark bars over beers with scientists, not out in the open where colleagues could hear him and perhaps be offended. Similar to the talk I overheard three scientists having about the bioethicist and the Gene Editing Summit, which I wrote about in chapter one, this diary was an instance of "real talk" about synthetic biology, and voiced a gutsy opinion that had the potential to spur more debate and discussion about the values and norms that are emerging in the field. It moved me to consider what I think about this issue for myself. Furthermore, it reminded me of what Rabinow and Bennett outline as one of the maxims for "ethical vigilance" when trying to "flourish" in synthetic biology networks: the importance of speaking frankly about one's concerns

developed pitches, but not much science behind them. However, the science takes time, so it may just be a matter of letting them evolve before they have a working version of their idea.

in spaces of interdisciplinary communication and collaboration. "By speaking the truth frankly…the truth is made actual...it makes a life of science a bit more risky, a bit more worthwhile, and, if one is fortunate, a bit more pleasurable." (Rabinow and Bennett 2012: 179). Due to the nature of my affective investigation, "risky" and "pleasurable" feelings are certainly things I am interested in for Aurator's production, which I felt were present when I listened to this diary, and therefore this clip was accepted.

In another diary, this time recorded by the entrepreneur in response to the prompt where I asked if he thought synthetic biology had any limitations, I was taken aback when he said, "I don't really see and I can't really think of any limitations…" This revealed a lot about his faith, support, and commitment to the field as an entrepreneur who is trying to innovate within it, and possibly capitalize on it. He went on to explain that he finds the seductive qualities of synthetic biology to be everywhere around him when he simply looks out at nature. He recorded this while recording atop a grassy mound in Silicon Valley, peering out over the natural landscape of shrubs and trees before him, which he described in great splendour. The recording sounded performative, as though he were having his own Carl Sagan moment while looking down upon the vastness of the biological cosmos, inviting listeners in to appreciate its awe-inspiring beauty and the sense of wonder he feels when peers at it.

> "Right now, I'm sitting on top of the hills in Silicon Valley and I can see all of these beautiful plants that are unique to this area. Some of them have really funky tubular like structures…Some are completely green. Some are jagged…There's just so much diversity and it is just all programmed from one chemical, right? It is all programmed from DNA. When we look around us, the possibilities seem limitless and that's the most attractive and seductive thing for me about building with synthetic biology."

David Kirby is a scholar of science communication and science film who has suggested that we are currently experiencing a "wonder overload" that espouses an almost religious appreciation for the awe that science can generate (2015). He pinpoints popular science shows like Niel de Grasse Tyson's recent re-making of Carl Sagan's classic series *Cosmos* (in the US) or Brian Cox's *Wonders of the Universe* (in Europe) as

perpetrators of such a "wonder overload." Kirby argues that these programs use wonder as a framing device to attract and retain viewers from broad target audiences. Kirby suggests that these types of wonder-framed television shows and documentaries demonstrate how the scientific community is taking wonder away from the religious community as a means by which people can understand their relationship to the natural world. "But, the problem is that science documentaries are never content to leave it at a sense of wonder/enchantment for the natural phenomenon itself. They inevitably resort to saying that we can be even more in awe of these phenomena because we understand how they work or can at least contemplate how they work. The wonder/enchantment is always re-directed away from the thing itself and towards our ability to understand the thing. This actually contrasts with natural history or wildlife films. Those films often allow viewers to marvel in the spectacle of nature without having to constantly remind viewers about how much we can know about nature." (2015). Kirby points out a danger of wonder overload that constantly reminds viewers of the scientific community's ability to understand this wondrous natural world: it could create the illusion that scientists are never wrong.

Kirby's critique of "wonder overload" can be used to analyse what the entrepreneur said in his diary as he explains how the most "attractive and seductive thing…about building with biology" is using biology as a raw material to build things with when it is so awe-inspiring already on its own. The ability of synthetic biologists to harvest that wonder, understand it, and then, do something useful with it, is a big motivating factor in his work. I decided to add this diary to Aurator because it touched on his deepest motivations for working in synthetic biology, and felt to me, as a listener, as that there was some kind of performativity to his science communication. That performativity of speech felt as though it was meant to affect a listener, by passing that awe-inspiring sense of nature and synthetic biologists' ability to build things with it, onto them.

Interestingly synthetic biologist 1 said something very similar to what the entrepreneur said in one of his diaries when he talked about what fascinates him most about synthetic biology. He recorded that diary while he was staring out of his office window, looking out at the nature that lay on the other side it: several trees in a parking lot. In that diary, he interprets what he is looking at as more than just trees, calling them a library of tools "to build limitless things with." Similarly, the biohacker talks about the "mind-boggling beauty" he encounters when he looks at the structure and function of proteins. From their diaries, it would seem that all of the diarists who are trained as synthetic biologists (the entrepreneur, synthetic biologist 1, and the biohacker) are drawn to the field partly because of the unfathomable power, sophistication, and wonder of the natural world. But even more so, because of their ability as synthetic biologists to wrangle that wonder and understand enough about it in order to design and build new wondrous biological systems with. Kirby argues that the way this functions as a communication tool is to aggrandize the general perception in society that scientists "have it right" in terms of their understanding of the natural world, as opposed to religion, for instance. Since they can take the enchanting powers of nature and make it perform in ways that they design, then they must possess a superior form of intelligence to that of nature on its own, or religious knowledge. In other words, in this case, it serves to bolster the claims of synthetic biologists and their potential to change the world in the ways that they set out to. I also added this diary for the same reason that I added the entrepreneur's diary that was recorded from the top of a hill in Silicon Valley: it epitomizes the synthetic biologist's reason for doing what he does, and taps directly into his passion for being a synthetic biologist - the most affecting connection there is.

In another instance, I experienced a strong urge to add a diary to Aurator when I heard a section of synthetic biologist 1's tape where he said:

> "I've become more political or you could say I give more political answers when I talk to lay people about my work. For example, I refrain from using words like "we modify" or "we

> genetically engineer nature" or some of these terms, instead I would say that we are making or constructing 'optimal agricultural entities.' It could be nice to say things as they are, but when you go in public in larger settings, then you are reaching some people which might have very strong opinions and who will guide the discussion into a whole different level where it is very based on feelings…in order to not trigger those people I end up using these very cushioned terms to explain what we are doing with our science."

He went on to explain that formerly, he used to give more direct answers to laypeople about what he was doing with his synthetic biology research, but he was later trained by the university department he works in to give "more political answers." He calls them political answers because, he says, politicians steep their messages in the most positive terms "even though the real message might be really bad." He admits, rather nonchalantly in this recording, that he tries to prevent people's dissent or discomfort towards his research through strategic communication, and moreoever, that this was something he had been trained by communications professionals in his workplace to do. In other words, he shares how he has been taught, in some regard, to perceive laypublics as a disembodied mass of mistrusting voices that require closed forms of tailor-made communications that couch things differently than he otherwise might present them for audiences that include scientists like him. This fear of the public's fear of synthetic biology is what Claire Marris has called "synbiophobia-phobia" (2014). It can fuel what Nordmann calls "speculative ethics" (2007) whereby decisions are made for how to treat or approach ethical considerations of a technology based on assumptions about what society thinks of that technology. Again, this is a moment of a synthetic biology expert using "frank speech" (Rabinow and Bennet 2012) to voice their concerns, and the frankness of that speech, particularly due to its controversial nature which could cause more engagement to emerge from it, is what moved me to add this diary into Aurator.

Other times I found myself adding diaries into Aurator was if the diary content spoke to some kind of academic argument about a so-called paucity in the field. If I noticed that a diary was speaking to an issue that scholars had raised as a "problem area," I could be intellectually moved to include

it in an effort to diversify the discourse on synthetic biology in the polyphonic fashion that this project is motivated by. My ability to notice this depended on my existing knowledge of the discourse around synthetic biology, and so I could not assume that including this diary on Aurator would move a user at some point in the future, whose knowledge of synthetic biology discourse I will never know. Instead, my decision to include the diary stemmed from a scholarly preference to align myself with my theoretical framework wherever possible. For if a concept is allegedly "missing" from the discourse, then inserting it into Aurator would, in some small way, diversify the number of voices making claims about that point, helping to fill the paucity and add to the "heteroglossic force" and thus polyphonic quality of speech on that issue. One diary that affected me in precisely this way came from the social scientist, when she said:

> "Will synthetic biology deliver on its promises? It has got itself into a position where it is promising many useful products, jobs, economic growth, so one of the unknowns is whether that will happen…I suppose what I believe is true about synthetic biology is that it has excited many people, it has resulted in large amounts of funding and branding across the globe from governments, industry and the military…But we still don't know, is it even possible to engineer biology?"

In that diary, the social scientist raises further questions about the fate of the field and the political tensions that run throughout it, asking whether or not it will still "be a thing" in the future, or rather be forgotten in the long history of innovations humans have created before. In contrast to that uncertainty, she claims what she does know for sure is that synthetic biology has excited large groups of people and amassed a following for itself that includes impressive amounts of funding as a result of a strong branding initiative that has crafted narratives that legitimate the field as something worth investing in.

This speaks to directly to a point that scholar Kristin Hagen says is missing from many engagement projects in the field, as she puts forth in the critical passage below. Consequently, I added the diary wherein the social scientist makes an explicit recognition of what Hagen points out, in the hope that

it may be useful to Aurator's future visitors so they can glean something about the internal power struggles in the field.

> "The main problem about the synthetic biology engagement and legitimization narrative is that it fails to make into account the political dimensions inherent in the ethical and social perspectives… The science policy landscape is challenged by these political tensions: there is a vested interest in synthetic biology as a potential source of innovation for economic growth and/or solving grand challenges, and there is at the same time responsibility to ensure oversight in the light of risks, uncertainties and broader ethical and societal considerations. Publicly funded research about the societal implications of synthetic biology needs to take such tensions into account." (Hagen 2016: 210).

This is an example of my discursive knowledge of the debates in field leading me to accept a diary. Though this may be a limited method, as Aurator's future users could perhaps not care less. My decision to add it serves a heteroglossic function, hoping to expose as many critical viewpoints as possible.

Furthermore, I experienced a surge of curiosity about and connection to this critique which made me reflect on the limits of my own split role as a science engagement practitioner and scholar in the field. I worried that by producing Aurator, my own engagement work was supporting yet another legitimization narrative that sends the message that "this field is worth talking about" at a time when experts aren't even sure about the basic tenet of the field. For as the social scientist asks, "is it even possible to engineer biology?" I became concerned that future users of Aurator may not know that I have grappled with these arguments, because the project itself, in all its polyphony, flattens the hierarchy of topics that are highlighted across the diaries and thereby obscures explicit grappling with these kinds of political tensions that Hagen refers to. I will consider this point further in my discussion chapter in a section called "The limits of engagement: how critical can one be?" These reflections affected me and they caused me to add the diary that provoked these thoughts into Aurator, partly in an effort to try and grapple with these tensions that Hagen's scholarship points out and that the social scientist's diary connects to.

Furthermore, the social scientist communicated her ideas in a direct and forward way, connecting to my interest in "frank speech" about the field.

Lastly, another prompt-genre that I chose to add a diary from was when I felt affected by the absurdity, playfulness, or brazenness of a critique that came roaring through a diary. These are three adjectives that I would describe many of the artist's diaries with. Absurd, playful, and critical diaries could make me laugh, make me imagine, and make me think hard – they vibrantly affected what came next in my own thought process about synthetic biology after hearing them. The artist is a type of exhibitionist who communicates critically about science through artistic interventions for a living, and he is very effective at producing provocative communications about synthetic biology.

The few times where I have shared the following diary excerpt from the artist in front of audiences at conferences where I have presented this research, people in the room have always burst into laughter, immediately revealing something about how affecting the diary is. I had already presented it in a conference and experienced this audience reaction before adding it into Aurator, which helped show me why I should include it in the final public engagement project. If it could make a room erupt with laughter, then it might be able to make an individual user laugh at home as well, as I had when I first heard it.

> "The first time I put GFP *(green fluorescent protein)* into E coli, that was neat. It is not a very complicated technique, it is very abstracted, but the morning after when you see those glowing bacteria and realize that what you did was facilitate sex between a fragment of a jellyfish and a bacteria to make something new, something that never existed before - a bacteria that glows green but that green protein actually came from the jellyfish - it is a very strange moment…(Synthetic biology) is a morbid kind of fetishistic sexually driven desire to control and engage with other living systems."

When I presented this quotation to a room full of synthetic biology PhD students at a conference, they audibly guffawed and cackled. They seemed thoroughly entertained, which would be no surprise to the artist, who calls himself an "exhibitionist." *GFP E. coli* are as rudimentary to them as recording audio is to me, and to hear this mundane laboratory process re-contextualized as a fetishistic and morbid sexual act

was beyond their comprehension as anything but absurd. The perceived absurdity made itself known through laughter, but after a few moments, the room quieted. The stillness in the room provided them room to reflect on what they'd just heard. Then, a student who had first laughed loudly in the front row raised his hand, "What else does that artist have to say?"

In this sense, the performativity of his critical discourse is doing what it is meant to do – perhaps entertain, but more importantly, ignite further discussion and debate - causing people to consider a scientific topic from a totally new angle. Since this is part of what I want Aurator to do as an engagement platform for affective communication about synthetic biology, I added the clip.

In a separate diary, the artist gave a very original critique of synthetic biology that I had not come across before, and its originality moved me to ponder it for a rather long while. Noticing the surprise and interest I felt with his perspective, and its ability to push me to consider something about synthetic biology that I had not before - "the fallacy of the human as a rational being" - I accepted the diary and added it into Aurator. This was an intuitive way of choosing that I will explore the limits of in my discussion chapter. The artist said,

> "There is a problem with the whole idea of engineering biology because engineering mindsets are driven by understanding the system and building it from the bottom up in what engineers like to talk about in terms of rational design…in order to understand processes you kind of remove the noise from the system because you are trying to concentrate on the process you are trying to manipulate. Again, this is in the language of synthetic biology. There is a lot of discussion of trying to remove the noise from the system. But in my perception, life is the noise. Once you remove that noise from the system you might have a functional system of sorts but it won't be alive any longer. So, it won't be biology…You know engineers, more than most other people actually, believe in the fallacy of the human as a rational being. So, the idea of rational design when it is being applied to biology in synthetic biology is in my perception, fundamentally flawed."

1B) Being moved to reject diaries for use in Aurator while listening to them

There are many factors that would cause me to de-scribe or not select an audio diary excerpt for use in Aurator, ranging from poor technical recording, to meandering incoherent thoughts, to off-topic

speech and more. However, in all cases, a constant factor that helped me determine whether a diary was good to add was my impression of the communicating experts' self-concept as a science communicator, based on what they said in their recording and importantly, how they said it. To recap, Baram-Tsabari and Lewenstein identify one of the "strands" of learning science communication successfully is when a person takes on the identity as a science communicator (2017). That is, when someone has learned to think of themselves as a good communicator and is willing to, for example, participate in science communication activities and confidently galvanize resources and the community around them to help them perform as a science communicator. If and when the communicating experts sounded to me as though they felt like they were doing well at communicating from having learned something about what comprises "good" science communication (through clear cadence, pointed description, strong opinion, fully-formed argument, etc.) that signaled to me that they were performing a kind of communication that was worth giving a chance for Aurator. If I detected the opposite though, then that would be the grounds for a diary's rejection.

As Baram-Tsabari and Lewenstein point out, the performances that constitute confident self-identifying science-communication are not necessarily inherent qualities of the speaker, but something that a communicator learns. In this project, the likelihood that the communicating experts have already learned to identify as a science-communicator is high because they self-selected their participation for an explicitly communication-based science media project. However, as was observed in a few instances, such as when the watchdog felt discouraged by my telling him that his recordings would make their way into a documentary-style media project for the public rather than only be heard by academics, this identification was not always uniformly distributed amongst my diarists. Plus, communicating experts did not always seem up for the task of performing as a self-identifying science communicator, again, in the sense that it is not an inherent quality of the speaker. Sometimes they sounded tired in their recordings, or particularly slow in their speech or idea-generation, or generally dissatisfied with the exercise, rushed, etc. In those

moments, I would not select their diary for Aurator. It is fairly obvious as to why a media producer would reject content like that from a project they hoped would have affective resonances an audience. However, I include this in my analysis to point out that a communicating experts' identification of having learned science communication is only one layer of success that determines how their communications will or will not make their way into an engagement event, on account of their own participation and delivery. I want to make explicit that there is also another layer that is controlled by the engagement producer, who uses their own subjective perception to judge how and whether that communicating expert is performing their knowledge as a science communicator. Therefore, just because a person learns to identify as someone who communicates science, it does not always mean that they *will* communicate science in a particular setting at a particular time.

This can be understood similarly to how qualities such as trust and credibility are not inherent things that certain science communicators (or experts) possess. Instead, it is the audience that decides whether or not a science communicator or expert is trustworthy, which are opinions that get formed according to the experiences and values of the audience members (Kahan 2013). In the case of credibility, although a science communicator may feel they are a very credible source, and identify as such, their credibility is not an inherent quality that audiences will automatically recognize and respect. Instead, their credibility may be bolstered by certain audiences, and completely torn down by others, depending on the audiences' personal values, beliefs and perceptions. As the National Academy of Sciences Report of Communicating Science Effectively says, "In science communication, the audience decides whether communicators as sources of information, or the institutions they represent, are credible and trustworthy. People use these assessments to decide what information to pay attention to and often, what to think about that information." (National Academy of Sciences 2017). Similarly, in the point I am making, it is the engagement producer who decides if the science communicator is good at performing science

communication. Their ability to communicate is not an inherent quality that engagement producers will automatically recognize in them. Instead, they will be judged on it. In other words, the engagement event's producer decides whether communicators – and products of their communication - are effective sources of communication to be used in an engagement event long before audiences even show up and can judge for themselves whether or not they feel that communicator is a good communicator (or a credible or trustworthy communicator, as the case may be).

Furthermore, the audio diaries were also sometimes replete with banalities, mundane reflections, purely scientific descriptions or specialist jargon. Because my aim with this project is not to educate users about the science of synthetic biology, but is rather to generate reflections on the social entanglements of the field through emotional and affective engagement, I was not interested in including didactic diaries if all they were doing was conveying scientific information. Moreover, it is difficult to make banal, mundane or jargon-filled recordings worthwhile for other people to listen to. Their lackluster or alienating content distances users instead of pulling them in, and consequently diaries like that would not be selected for use in Aurator.

A typical example of something I would have rejected from Aurator is the following excerpt from the synthetic biologist:

> "Proteins are these little polymers of amino acids that are nanotechnological machines that are basically what make us alive. So then maybe they understand proteins or what a protein is, but then do they understand the chemistry that proteins cause? The enzymatic reactions that cause them to do certain things, or the thermodynamics which cause their function to happen."

Although this excerpt may be interesting when framed through the lens of science education, I did not include it in Aurator because my explicit goal for the project was not an informal science educational one. This excerpt was part of a larger monologue about the functions of chemistry, which included little

personal reflection. I did not feel moved when listening to it, and therefore this clip was not selected. Another example, which I rejected from using in Aurator for the exact same reasons, is the following excerpt from the biohacker's diaries:

> "So, say I want to put this plasmid, which is super commonplace in labs and do it all the time, companies like say IDT will charge you 3000 dollars. You can find places on science exchange that might be able to do it for 500 – 1000 if the gene sequence is really big or you want multiple genes in it, it becomes much more, so right now you're talking about putting it into plants. Nobody's going to want anything simple, no they're probably going to want something complicated, right?"

Due to the specialist jargon and technical description, I nearly wanted to fast-forward through this section when I heard it the first time, which indicated to me that it would not be wise to add it to Aurator for others to hear. This however of course makes assumptions about the interests of future users, as though they would somehow match up with mine, which is an unknowable thing, and therefore this methodological way of analyzing the data certainly has its limits.

2) Feeling the pressure to produce

In the second year of my three-year PhD, several months after I had solicited all of the communicating experts' diaries and completed my post-project interviews with them, there came a time when I was feeling acute pressure to begin Aurator's digital production. I had a PhD to complete and a platform to build that I wanted to be used by real people out in the world, and time was starting to run out. I knew that the actual production process could take an unruly amount of time, as media projects often do, made especially likely by the fact that it was my first time ever making an interactive digital project. In this section, I analyse how these emotional and affecting pressures to produce influenced the way I marketed and sold the idea of Aurator to funders in order to make it possible, which had a direct effect on the final engagement project's outcomes.

I wrote a successful grant application to the Social Sciences and Humanities Research Council of Canada in order to procure much of the required funding to make the practice-based component of this thesis, however the budget still required a considerable amount more. As I was searching, I was approached by the director of a British synthetic biology institution who had heard about a talk I gave at a conference on my research about the diary solicitation project through a colleague. He was interested in learning about my work and said that there may be an opportunity for me to partner with his institution on a variety of outreach projects, as his institution was quite new and they were actively looking for ways to expand their public engagement portfolio. At one point, we discussed the fact that my research does not fall into the category of public outreach, understood as promoting synthetic biology to society, but focuses instead on public engagement, which is about creating fora where emergent conversations and debates about synthetic biology can take place. Therefore, a partnership with me might not serve his institution well if they are specifically looking for promotional partnerships. He said he understood, and was interested to work with me anyway. One of the first things we decided to work on together was a course about the Ethical, Social and Legal Aspects (ELSA) of synthetic biology, which he hired me to create for PhDs and post-doctoral researchers at his institution.

Some months later, it became apparent to me that we were using different definitions of public engagement in our work, despite our earlier conversation. This was clear, for example, when he introduced me to the classroom full of PhD students and post-docs on the first day of the course I created for them. He told them that I was there to engage them in a variety of lectures, case studies, and exercises that would be important for them to participate in for several reasons. Specifically, he said that there was a government funding push in the UK for ELSA-related activities in synthetic biology, and therefore it was important for them to learn about what this course had to offer because it is connected to funding trends that will influence their own research in the future. In other words, there was a utilitarian outcome they

could expect from the course, which would increase their ability to write successful funding applications. However, my course description explicitly stated that the course "is not about selling the science of synthetic biology." The director also told the students that the course is important for learning how to bring key aspects of synthetic biology across to publics, because it is "exceptionally important that what we do, as synthetic biologists, is seen as acceptable and desirable."

For the course, I was interested to have genuinely open-ended discussions with the students about the ethical, legal, social, artistic, design, and communication-related aspects of the field. I wanted to hone their critical thinking skills in these areas and get them questioning synthetic biology in ways that they might not otherwise have done. But I didn't want to begin the course by publicly correcting the director on my intentions in front of the students, so I brushed our misunderstanding off and didn't think much more about it over the two full days of teaching. However, I would be reminded of it again and again throughout my fundraising process for Aurator with his institution. Fortunately for the project, we continued to work together after the course, and the director expressed interest in funding the remaining amount of money that was needed to build Aurator. But in order to have his institution fund it, he would need to convince the board of directors that their institution should sponsor the project.

The director was very helpful in sharing pointers with me on what might help convince the board that they should settle on a certain amount of money to fund Aurator with. Most importantly, he said, "sell it this way to them:" the platform will build a sense and place for publics to interact directly with scientists and get the truth from them. "If you can build a place where direct interaction takes place and people feel they can trust scientists, then that is ideal," he said. It would be very helpful, he advised, if I could present this trust-building aspect as the explicit goal of the platform to his institution's board in a written pitch package. Further ideas that he was interested in me developing in the written pitch package included an elaboration of the platform as a mechanism for gathering feedback from groups that they

regularly engage with at outreach events, such as high school students as a focus audience.

It was fascinating but not surprising to learn that he believed the board would want to spend money on supporting Aurator if it were explicitly framed as a tool to promote transparency and build trust between laypeople and their institution's synthetic biologists so that public trust in synthetic biology may be strengthened. The issue of building trust is an understandable concern for the board of a synthetic biology institution to have. In biotechnology in particular, researchers have expressed concern that the enormous amount of hype and optimistic coverage that is often associated with its innovations (for example: personalized medicine, synthetic biology, genetics and genomics research) can do damage to whatever trust publics may have in biotechnologists. This happens, it is argued, because such biotechnologies are hardly ever able to live up to the enthusiastic language that they are described to publics with, and there becomes a need for damage control once publics discover or feel that they've been let down, lied to, or duped (Brown 2003, Caulfield 2005, Petersen 2009).

I have already written about the tensions institutions face as they attempt to engineer public trust in my methodology chapter, where I use Brian Wynne's work as a lens to understand how the pursuit of public trust can be disingenuous, as "it is a contradiction in terms to instrumentalize a relationship which is supposed to be based on trust." (Wynne 2006: 219)." According to Wynne, scientific institutions often imagine their publics as they try to engage with them as a means of cultivating trust. They imagine what publics think instead of *listening* to their publics first in order to foster meaningful open engagement experiences that respond to their genuine concerns and feelings. At that time, I was feeling the pressure to produce Aurator, and I was sitting on the precipice of a potential funding package that would finally allow me to make it. This forced me to make a compromise among my priorities. On the one hand, I needed to make Aurator exist somehow, and the bottom line was that I needed this funding to enter production. Therefore, accepting the funding would have to be my first priority. On the other hand, I wondered if the

synthetic biology institution, which had its own agendas and interests, would potentially transform my research into more of an instrumental engagement project than I had set out to make, if I accepted their funding. Would Aurator, if described first and foremost as a platform for engendering trust between publics and scientists, serve primarily to allow scientists to "tick the box" on grant reports that demonstrate they have carried out the kinds of "engagement" activities that their funders expert from them? Over time, as my relationship with the institution grew, I became more concerned that Aurator could become trapped as a tool that services synbiophobia-phobic funders before it creates space for meaningful, "emergence model" style engagement (Horst and Michael 2011). Despite my concerns, I decided to take the funding anyway, because I cared more that Aurator get produced than I did about the nuances of its engagement effects. This is a considerable compromise to make, particularly when one does not yet know what the effects of taking the funding will truly have on their research outcomes, however it shows very clearly how caring for one aspect of a science communication event can mean neglecting or removing care from another aspect of it. This relational interplay between objects, that govern how care is administered, is well documented in scholarship about the phenomenon of care (ex: Mol et al. 2010, Myers et al. 2012, Martin et al. 2015, van Dooren 2014, de la Bellacassa 2017).

Although that concern was brewing, the stronger feeling I had was the pressure to produce. I was becoming heavily affected by my personal desire as well as my academic need to have something to show for the practice-based component of this thesis. As mentioned, I had already obtained a large grant from the Canadian government to fund Aurator's production, but it was not enough to hire the necessary programmers and I was eager to find the remaining required funds. I listened to the director as he gave me tips on how to convince his board of my project's value for them, and proceeded to strategize with Oertelt on an updated pitch package that demonstrated what he told me. We changed the interactive concept in the pitch from focusing on archiving and sharing audio diaries about synthetic biology from diverse

perspectives in the interest of emergent dialogue and debate, to focusing on how the interactive format can provide an unique access point for publics to reach experts via intimate audio diary-based conversations, in order to promote transparency and trust between them. This shift in the pitch assumed that trust could actually be cultivated by such an activity, without any experimental evidence for it. And it worked. The board agreed to provide the remaining funding that I required to hire Helios Design Labs to build Aurator, and we quickly got down to work on the digital aspects of its creation.

However, the implications of this shift in my pitch in order to obtain funding did not materially change the way that we built Aurator. Aurator highlights the diaries of diverse communicating experts just as it was intended to, and provides users the ability to speak back to their diaries in the spirit of debate or comment, as well as to create their own new audio diaries about synthetic biology on the site. What my encounter with the synthetic biology institution's director and board therefore demonstrates, is that the producer of an engagement event is vulnerable to a variety of affects throughout the preparation, fund-raising, design, production and execution of the engagement event that could change the way they communicate about the engagement event in terms of its purpose, motivation and goals in its marketing to funders and users. This is an ongoing process of negotiating between tenuous form of care for the project. It is a tenuous form of care because on the one hand, my pitch to the board could have somewhat jeopardized important theoretical underpinnings that frame this engagement project, which form part of its methodology and critique the instrumentalization of engagement, while on the other hand, if I had not done this, I cannot be sure that I would have been able to create Aurator in the time I had left. Without that funding, surely no engagement would take place, and interestingly, the way that I marketed the project to the synthetic biology centre's board of directors did not change anything material about the way that Aurator was actually built and therefore exists in the world.

Instead, the marketing tactics simply created a new narrative about its function in order to convince the board of its use for them. Caring for the project means many things at once, such as caring that the project gets made and can follow through on its engagement ideals, while also caring for the integrity of its intents and theoretical inspirations. However, due to the emergent nature of affects that can appear throughout a dynamic engagement and production process, some of which overpower others, "caring for science communication" may entail slipping away from pre-configured forms of care tied to specific science communication values and theoretical narratives, in certain ways at certain times, in order provide the care that is required to make the engagement project possible at all.

3) Ethical conduct as an engagement event producer

This section involves a discussion of the ethical dimensions involved with how I create new representations of communicating experts' diaries through the media production process. I use Howard Becker's thinking on "the morality of representation" in his book *Telling About Society* (2007) as a way to analyse how my role as a "maker" has ethical implications when editing, accepting and adding diaries, as well as rejecting dairies for Aurator's public-facing production.

As I have explained, part of my role as a practice-based researcher in this study involves representing my diarists to publics by transferring the audio diary data they give me into media fragments that comprise Aurator. As a media producer and practice-based researcher profiling and remediating the intimate (privately recorded) audio diaries of communicating experts, I am inherently involved in a process of "telling about society," as I explained in my methodology chapter (Becker 2007). Becker argues in *Telling About Society* that there is an ethics of care wrapped up in how the person "telling about society" must respect a mutually agreed upon moral pact between the "teller" and their research subjects (2007). In this ethics of care, one must not "pull any surprises" on their research subjects, just as I strive to not pull any

surprises on the communicating experts in terms of how I edit their words and add them into Aurator. However, a featured ethical concern I faced when selecting diary tape to use on Aurator is classical to all journalistic endeavours and empirical research processes. It involves the fact that I am editing (selecting and rejecting) other people's stories and streams of consciousness (data), affecting how they originally communicated them in their own words. At times, I make cuts in their digital recordings, make rearrangements, deletions, or other such edits that portray my subjects' thoughts in ways that they might not prefer compared to an alternative treatment I could have chosen. My point in doing so is always to clarify what they are saying and sometimes make it more succinct, but of course they could have different opinions about that. There is a natural tension here - one that's ever-present in my other radio work - which is the basic fact that I am using other people's voices, and reconfiguring them into an assembly that shapes a media project according to my creative direction. From the beginning, I had given my diarists some editorial control in the sense that they could decide what tape they handed over to me from what they recorded and could additionally always tell me to strike things from the recordings if they changed their minds at any point. But they were still expected to trust me as an editor, as Becker points out; to have faith in my intention to retain the integrity of what they had said in its full meaning when editing and adding their diaries to Aurator. To the best of my ability, my editing process was guided by a grounded ethics: respect and empathy for what it would feel like if someone were to ever break a moral contract with me. This folds into what I call *caring for science communication.* As I was doing the analysis for this thesis, care became an important emergent theme and I will be coming back to investigate what it means to care for science communication in this way in my conclusion.

But first, my ability to care for my science communication in this project has always been an important ethical ambition, but never a perfectly executed practice. As was evidenced by the social scientist's request for me to take down several of her diaries from Aurator once she saw them online,

something about the pact between us – in terms of her personal understanding of the engagement process - had been in some sense violated and betrayed. It affected her enough for her to ask me to take some of her diaries down. Although she said she understood intellectually the whole time that her diaries would be made public, she explained that after she saw them online, she never understood while making the recordings *just how public* and *exposing* of her inner critical thoughts about synthetic biology the project would be. Something about the audio diary recording process drew more out from her than she was comfortable sharing in public. This exposed a danger that exists with the private recording process: the intimate audio diary method may misguide communicating experts about their perceived sense of privacy. They may forget or lose sight of how public their contributions will become at some future point, affecting the way that they make their diaries. For the social scientist, she would not have spoken as openly and frankly in her diaries had the method reminded her in some way that she might feel very uncomfortable with those diaries being public. Instead, she got lost in the "streams of consciousness" that the diary method invites diarists to explore by themselves in the comfort of their own home or office or otherwise self-controlled space. As a result, she said things she would not have had she *felt* during the diary solicitation process that these recordings would become public enough that her synthetic biologist colleagues may one day hear them.

This of course highlights an interesting point about affective engagement: it may produce experiences that require ethical vigilance from the side of the engagement event producer. As already mentioned, I did not have to take down her diaries as she requested, since I had a signed consent form from her saying that I could share her diaries in a forthcoming public media project. But I needed to take responsibility as the event producer for the danger of the method itself. I learned that this method could cause communicating experts to forget *just how public* their diaries could become and therefore make them

feel vulnerable and anxious after the fact. To wit, the social scientist said "seeing it all on a website just brings home how public these comments - which felt very private at the time - have been made."

The sensitivity of this method, and its dangers for communicating experts has emerged as an important theme in this thesis, and stands against a back drop of research on audio diaries that often points out their potential benefits for diarists. For example, research on psychological stress has theorized that "cognitive restructuring" occurs when stressful events are recalled and reframed as a strategy for adjusting the perception of those events into something more manageable (Skinner et al. 2003). Storytelling theory has argued that telling stories about recent events can enable the reforming of personal judgments towards such events and one's role in them (McGregor and Holmes 1999). Therefore, Crozier and Cassell have argued that audio diaries may provide a method for "cognitive restructuring" in action, whereby the verbalization of stories about recent events allows diarists to minimize their stress around certain occurrences (2016, p 402). In this way, audio diaries become a way of making sense of one's life and what has happened to them, reconciling difficult emotions into understandings that make life easier to bear. Audio diaries are therefore partially understood by some social researchers as cognitive tools for psychological self-betterment and self-care.

Furthermore, as I've explained in my methodology, while such research points out the possible advantages of audio diaries for diarists, Monrouxe particularly highlights their potential advantages for researchers. Because audio diaries give enormous control to the diarist, the researcher has a minimized effect on what data is collected since the researcher is not present when recordings are made. This is advantageous for the researcher, Monrouxe argues, because it allows for private and sensitive information to be accessed which the diarist might not feel up for sharing if they were not the one fully in control, or that would be practically impossible to record with another person present (2001). However, what might be good for the researcher in a given situation, particularly if they are interested in extracting intimate and

affective stories from their diarists as I have been in this project, might not always be good for the diarist, as evidenced by the social scientist's concerns and reported discomfort with her audio diaries being public. This inability to care equally for both the diarist and producer's needs in all cases at all times, clarifies a crucial tension with this method. There is an insurmountable tradeoff that forces an engagement producer to determine their own ethics of care and act accordingly. Who will they show more care for in the way that they produce the engagement project – their diarist or themselves?

Similarly, when the biohacker first encountered his diaries on Aurator and cried twice as he listened, he said, "When I listened, it made me cringe a little thinking about how people will react to it. Especially given that the diaries were done a year or two ago and stuff has changed since then." Both his case and the social scientist's demonstrate how this method can create serious perception issues, leading communicating experts into a space where they become comfortable divulging personal thoughts and opinions, while they have little idea of how they will feel about them becoming public in the future. Furthermore, there is no mechanism in place to remind them while they're recording that they may feel differently about their comfort for sharing what they're saying when the recordings are made public and they perceive them in an entirely new context than the one they're currently in. Although the biohacker followed up by saying, "But I said it and that is me and I want to be me unabashedly" other diarists, such as the social scientist, did not feel committed to standing by what they once said based on the principle that they had said it and therefore should be accountable for those words. I did not automatically reject the biohacker's diaries from Aurator that had made him cringe or cry because he did not ask me to. When I asked him if he wanted me to, he said no, and on the contrary, explained that he wanted to stand by what he says more in the future. However, I removed several of the social scientists' diaries from Aurator as she had asked me to. Both are instances of me trying to negotiate the necessary ethics of care when doing

engagement work, according to a dynamic, emergent set of relations with the communicating experts and the outcomes of the engagement project that were not able to be foreseen from the outset.

As Becker argues, the moral pact between "maker" or "teller" and their research subject should recognize that what is acceptable in terms of how the participants are being represented – by me in this case - is not agreed to in "some self-conscious, document-signing way" (2007: 135). Instead, in these moral agreements, it is fair to suppose that people agree to it as long as they participate in the activity "even as one becomes aware of all these tacit understandings." And as I explained in my methodology, in order to determine if the tacit ethical agreements between the communicating experts and myself are being honored, I pay attention to where their co-operation to participate endures and where their co-operation to participate breaks down. When the social scientist asked me to remove some of her diaries from Aurator, I interpreted this as an act of participation breakdown, and therefore it was only ethical of me to respond to her discomfort with an ethics of co-operation, regardless of having a consent form from her that would have protected me to do otherwise. I wanted to care for her discomfort, and felt empathy for her fear of being judged by her colleagues, so I assisted with her request to a point where it started taking a significant amount of care away the way I was treating my own project. That is to say, that there was a judgment I needed to make about how many diaries I could remove in order to respect the emotional response she was having to seeing them, without taking so many away that Aurator started to lose a damaging amount of its particularly interesting diaries. This type of judgment and negotiation requires the affective and emotional concern from the engagement event producer as guided by an ethics of multi-faceted care (a balance of care for the diarist and care for the project's outcomes). In the next section, I will discuss more broadly what the notion of care means for science communication and why engagement event producers would do well to consider it explicitly constitutive of their work.

Chapter 6: Discussion

I have demonstrated in this thesis that the participation of communicating experts in an engagement event is shaped by emotions and affective experiences that emerge throughout the event (their own emotions and affects as well as those of the engagement event's producer). I have also shown that the emotions and affective experiences of the event producer determine a variety of outcomes of the engagement event that inhabit valences of varying influence, though are sometimes strong enough to overpower how communicative experts take up or resist their roles as participants, such as when the producer judges whether or not the communicative expert's performance as a science communicator is convincing, moving or "good enough" for their communications to be included in the final engagement output.

My findings have led me to make one principal argument about the function of emotion and affect in science communication, which is that a science engagement practitioner must always *care for science communication* – that is, apply a deep knowledge and delicate balance of competing requirements for care when practicing "emergent" science communication (Horst and Michael 2011). Indeed, as Martin et al. have written, "we cannot but care: care is an essential part of being a researcher and a citizen" (2015: 626). However, in science communication, we can (and should) learn to render more explicit awareness about how we do and do not care for our participants, our projects, and our potential future publics when producing emergent engagement events. The focus on caring for unpredictable, tenuous and conflicting demands that arise while science communication is being produced before publics even appear is a dimension of science communication practice that scholarly literature has yet to explore. I will return to discuss these points later in the chapter. Before that though, I must bring my attention to the affordances and limitations wrapped up in the way I was able to come to these conclusions: practice-based research.

What I've learned about practice-based research

I believe that practice-based research offers a rich opportunity to those who have a vested interest in keeping their creative practice alive while disappearing from industry for some time into the academy in order to foster a deeper understanding of concepts and methods related to their work. Indeed, this is what attracted me to do a PhD by practice. I am not, and have never been, interested in working as a professor or within the university institution full time. Considering my lack of ambition to be a professor through a limited, classical understanding of what a PhD enables one to do, it would then seem rather nonsensical for me to do a doctorate degree. However, I have been frustrated on many occasions by my experiences working in the media industry where the production timelines are short and demands are high to produce media for public consumption. This happens in settings that don't allow the practitioner the kind of time that is needed to research interesting aspects of their practice through reflexive analysis, nor foster a deeper understanding of scholarly concepts that interest them. Fortunately, the practice-based PhD relieves some of this pressure and creates an unique space to *research* and *practice* at the same time. It also allows the PhD student to return to their industry after they've defended with a new production in their portfolio, which may be able to advance their career. Therefore, most straightforwardly, the practice-based PhD is an exceptional idea for makers who are intellectually intrigued by the theories and practices that undergird their work and who also want to develop a reflexive practice for their future projects.

However, in reality, this exceptionalism is filled with trade-offs, both for the practice and academic aspects of one's work. While I do believe the practice-based PhD is a great opportunity for the practitioner who wants to return to industry, I am less convinced, that it makes sense for an academically oriented person who has no intention of developing their practice outside of the university setting, unless they are to perhaps focus on teaching practice-based courses inside their institution. In that case, I sense that a traditional written PhD would allow them greater opportunity to develop their scholarly craft. They

would have more time to develop their methodological skills as an analytical scholar and do deeper, broader reading than is enabled when one must use their allotted PhD research time to also create media or artwork outside of the written thesis. These are simple and pragmatic trade-offs related to time and resources, but practice-based PhDs also have conceptual limitations, creating compromises between scholarship and practice. I will demonstrate this point below with some examples of things that occurred during my practice-based research and production process.

It could be criticized that the way I analysed the audio diaries in order to add them to Aurator or reject them was not always convincing from a methodological perspective. Although I did use Felt and Fochler's "machineries for making publics" which I transformed into "machineries for making communicating experts" by taking note of how the communicating experts inhabited their roles as participants and how those decisions were shaped by affect and emotion, this became more difficult to do when it came to analysing my own decisions as Aurator's producer. When I was deciding which diaries to add and which ones to reject, my split role as a researcher-practitioner became very blurred, and I acknowledge that there were times when I privileged one role's interests over the other; there is no equal way to wear both hats at all times. When I was in my practitioner role making Aurator (selecting the diaries, making aesthetic decisions about its production, etc.) I had to prioritize the way it would look, feel and function for audiences at some future point in time, even though those audiences were not of any interest to my scholarly concerns. I had gone through a lot of meetings, negotiations and grant writing to raise the funding to build Aurator, putting both money and my sunken time at stake. If the project would fail to stand on its own after the dissertation was defended, much more would therefore be wasted than just my intellectual integrity. I would have rather found a way to embody to role of practitioner-researcher in harmony than put the practitioner's needs first. This dilemma meant that when I should have been equally focused on scholarly interests, my behaviours were at times overwhelmingly influenced by practice-based

sensibilities that Aurator required. These sensibilities were significantly guided by intuition and therefore could, at times, appear to be weakly executed from an academic perspective.

For example, in chapter five I wrote about selecting one of the artist's diaries for Aurator that cheekily discussed how synthetic biologists believe in "the fallacy of the human as a rational being" because "its originality moved me to ponder for a rather long while." This selection was driven by the practitioner in me and its preference for using surprising or entertaining clips on Aurator in order to intrigue imagined future users. When producing, I make decisions about what is surprising or entertaining based on my intuition and paying attention to the way it makes me feel as a listener. Indeed, affect is one of the major frameworks I use in this thesis to analyse my data, by "paying attention to the way it makes me feel", though I have already discussed the limitations of using such a framework in a scholarly setting. It can be difficult to describe, in scholarly terms, exactly how these affects come to matter for knowledge production when that knowledge is produced by creating something. Creating involves intuition. Selecting media while producing *is* an intuitive practice. Intuition *is* another way of knowing and of making (media projects, artworks, etc.) that aim to stir the soul (affectively), but this kind of description falls short academically, without doing a separate PhD about the phenomenology of art practice, creativity or cognition.

Intuition is described in the literature as a kind of unconscious processing (Runco 2007), a "hunch" or a "gut feeling" (Polzer et al. 1989; Isenberg, 1989). Langan-Fox and Shirley traced historical discussions of intuition and found that Baruch Spinoza thought it was "the highest form of knowledge" (Langan-Fox and Shirley 2003: 3), Immanuael Kant considered it a type of perception "supplied by the mind itself" (ibid), while Henri Bergson understood it as "the purest form of instinct" (ibid). Many scholars have explored the bridge between the unconscious cognitive processes of intuition and creativity (e.g. Janesick 2001, Runco 2007, Yukawa 1973, Nierhaus 2015, Raidl and Lubart 2001). The intuitive

sensibilities driving creative practice pose complicated questions for how to evaluate practice-based research, and what counts as "rigorous enough" scholarship when that scholarship is guided in part by an intuitive practice that is formed by one's experiences as a media producer, artist, or other kind of creative practitioner.

In my case, my scholarly analyses of my behaviour as my own research participant are partly bound up with a "feeling for the tape[26]" – an intuitive sense for the affect of what is being communicated in a diary, therefore guiding my judgments about whether or not to use it in Aurator. But this murkiness raises a problem. A scholar does not usually "feel for the data," they analyse the data according to specific methodological frameworks. Although difficult to back up, there are of some examples of how one can produce scholarly knowledge through embodied intuitive practices, as Evelyn Fox Keller demonstrated was material to Barbara McClintock's unparalleled career as a scientist researching maize in her book *A Feeling for the Organism*. McClintock had an intuitive unconscious approach to doing science that involved what she called "getting a feeling for the organism" that she believed her discoveries stemmed from (Fox Keller 1984). Similarly, Natasha Myers' ethnography of protein modelers demonstrates in great detail how they come to know the wriggling, bendable and contorting shapes of the proteins they study by engaging the researchers' entire sensorium. She explains how modelers develop a bodily feeling for the proteins they're trying to visualize that involve physical gesture, imagination and intuition in order to get a sense of the many molecular reactions they carry out, which even the fastest computers can't automate (Myers 2015).

[26] Although "tape" is an antiquated term from days of analog radio production when one would record on magnetic tape, today's producers still refer to digital recordings as "tape".

In the humanities, practice-based research provides an exciting opportunity to build on the legitimization of intuition, bodily sensoria and material affects as knowledge-making tools, which future research could look into, building on what's been written in recent years about "new materialism" and the liveliness of matter (e.g. Bennett 2010, Barrett and Bolt 2013). In order to *make something* (with media, art, etc.) that also produces new scholarship, we need to embrace the intuitive aspects of creativity and crafting (making) in the knowledge production process. Practice-based methods require new and different methods for evaluation, otherwise academics may be continually unsatisfied by the results of practice-based scholarship. However, coming to terms with how to describe intuitive methods in clear scholarly frameworks for practice-based researchers remains a challenging task. My experiences back up theoretical discussions about how challenging it can be to account for how knowledge is produced in practice-based research (e.g. Candy 2006, Candy and Edmonds 2012, Leavy 2015, Makala et al 2011, Tin 2013). Similarly, my learning reflects the point made many times in the literature that practice-based researchers must make considerations that go beyond what is normally required for PhDs in terms of how we know what we know and what legitimates art or media production as knowledge production methods (ibid).

Although I can locate instances in my study where I felt I was privileging the intuitive producer in me over the analytical researcher, at other times I felt I was privileging the opposite role. I once wrote in my research diary,

> "It's not possible to do both equally. It seems like I've been prioritizing the scholarly side over the practice. I'm not sure I would have made Aurator how I did if I were trying to attract mass audiences. Indeed, my PhD, as I've set it up, only requires me to study the production process of Aurator and how I gathered the diaries, not how publics engage with it, which so far has been a total failure. That whole public engagement part is not easily carried out on its own. Therefore, the scholarly side has been privileged, partly in order to care for the PhD, have something to write about, and get it done."

If I were trying to attract mass audiences with Aurator, as is a normative goal with a lot of my broadcasting work (partially since managers and editors these days care enormously about views, "likes," listens and clicks) I would probably not have made Aurator as experimentally as I did. It exists today as a subtle web-platform, without many visuals, dipping the user into a constellation of recordings from people they cannot be expected to care about or want to hear from. This makes very little sense from a broadcasting point of view. A broadcaster wants to hook their audience from the very beginning, making it extremely clear to them why they should stick around until the end of the media experience.

In contrast, the landing page of Aurator gives the user little information about what they are about to experience, but it lets them know where they have arrived. After one click they see a few lines of text "We once heard a saying that goes like this: 'In a room full of synthetic biologists, ask each one to define synthetic biology, and you'll get as many completely different answers as there are people in the room.' So what is synthetic biology?" They can click on that last "So what…?" question, bringing them to the next page, where they see the words, "Synthetic biology means many things to many people, though at its most basic, the field aims to engineer helpful, clever or "better" biological systems than what nature provides. It has made huge promises about its benefits for society, yet uncertainty remains about what its implications will be." Again, the interactive text at the end that the user can click on reads: "Why am I here?" Next page: "Aurator is a platform for public engagement about synthetic biology." Click: "How can I engage?" Then finally on the next page, the user enters the world of the audio diary archive. There are instructions on the left side of the screen about how to listen to the communicating experts' diaries as well as record and upload one's own diaries to the site.

What's problematic here is that the user has to click four times through five different pages before they can start the experience, which is a meditative and non-linear, unguided listening experience. By most normative accounts, this would not be the way to hook a user from the top, in all of its slow, text-

based cadence (as opposed to eye-catching video and photo, for example). However, I needed to set the experience up with an accurate frame for what my associated scholarship with the project was doing. I had to define synthetic biology, explain the goal of public engagement, and then provide some instructions on how to navigate and use the project, which is not inherently clear on its own. The user cannot just sit back, click play, and absorb information. They have to stick with it, follow each step, and come to decide how and if they'll participate. I therefore give them many opportunities to drop out along the way, with each click, where nothing much is happening before they come to the real action. And even then, the "real action" is a meditative world full of strangers' streams of consciousness and private diaries that a user must discover for themselves, although they may have no prior interest in synthetic biology and therefore may not care to. To wit, they haven't been told why they should care about synthetic biology, how it might change the world, and what specific problems or concerns that opens up. In order to discover some of that, they'll have to listen to several seemingly disconnected diaries, and it is not explicitly clear to them that they should. In my efforts to produce a platform for emergent engagement, I tried my best to not coerce the user to do anything in any particular way while still creating some format around the engagement experience. Towards this ambition, I left imperative statements one commonly finds in media narratives about synthetic biology, concerning techno-utopias or dystopias, out of Aurator's front-facing design.

I did not design the entrance to Aurator in a way that would produce strong emotions in the user that might cause them to stay (for example high energy music, shocking visuals, alarming words or scintillating excerpts from the most controversial diaries that just start playing on their own). Producing in that way, in an academic context, would have required reflexive justification for how it served my research goals in my methodology, which was something I felt methodologically incapacitated for, devoid of theories and frameworks to make it sensible. If I had designed it in such a way, I may have had more

success retaining users. If I had made Aurator as a practitioner only, and not a practitioner-scholar, I would have been relieved of these kinds of methodological constraints. I could have made the media project according to my own creative interests and audience objectives, without the need to academically justify my choices for doing so along the way. This could have had a material effect on the way the media project goes out into the world, interacts with users and comes to matter in their lives, but saying more about how it could have done this (for example, by attracting more users) would be pure speculation.

So far, Aurator has had very little engagement from internet users who are not already involved in the project somehow. This may be because of other serious limitations that the practice-based PhD posed on my ability to attract users. For example, I didn't have the time to do all the necessary distribution work that's required to promote a project online because I needed to focus on research and writing. I also didn't have the funding to hire a PR firm to do this for me, or an associate producer who was willing to pitch the project to potential partners such as The Guardian or New York Times that would then publish the project for their readers (this is how many i-docs have found their audiences in the past). Furthermore, I did not have the time, funding, nor an accepted pitch to take the project to major interactive media festivals (for example Sundance, Tribeca, Sheffield, IDFA) where it might find critical acclaim, audience engagement or media partnerships. These pragmatic pressures stem from the fact that I had other things I needed to complete as a practice-based scholar, which mainly meant being alone in a room where I could read and write within the time that was allotted for my PhD. My experiences have taught me that there are key trade-offs to what one can achieve in their production work when simultaneously producing scholarly work. There's not enough time, energy or resources to go around within the duration of a PhD timeline to do it all at an equally optimized level.

However, this doesn't preclude me from working in various ways to build a more significant audience for Aurator once my defense is over. Another fortunate thing is that my scholarly questions only

pertained to the production process of Aurator, not its actual uptake with members of the public as an engagement platform. That scholarly delimitation partially justified my working within the bounds of my time and resources, which has so far limited Aurator's audience engagement. But if I were to have made this project solely as a practitioner for the purposes of public engagement without any scholarly component, I would categorize Aurator as a failure on account of the lack of public participation it has seen so far. Although many people have visited the site, very few have responded to the communicating experts' diaries or uploaded their own new diary threads. Getting over this barrier to participation may require outreach activities, exhibitions, media partnerships, PR, user testing, and perhaps even a redesign of the user experience on the platform. But those are things that the time given for researching and practicing during the PhD does not permit one to comfortably do, let alone the funding.

As mentioned, the practice-based scholar must have a sound methodology (like all scholars) for how they make their practice-based work. Early on in this thesis, I explained that the theories I employ about interdisciplinary synthetic biology research networks, power asymmetries, synbiophobia- phobic narratives, imaginary publics, speculative futures, as well as the unstable role of art, design, and open practices like biohacking, has given me a political and aesthetic preference for emergent, reflexive and unpredictable engagement that I wanted Aurator to achieve. I wrote that I want "to create space for polyphonic engagement about synthetic biology in a Bakhtinian sense by highlighting the field's multidisciplinary voices, with their unique personalities, feelings, opinions, and attitudes about the field. I then want to open that polyphony up to wider publics so that affective engagement about synthetic biology may further unfold." By building Aurator the way I did, with its levelling of expert disciplines and subtle invitation to listen to polyphonic diaries in an unguided, unpredictable manner, which users may or may not respond to as a form of non-prescriptive participation, I do believe I've met my formal and aesthetic goals for the kind of forum I wanted to create. However, without actual audience participation (beyond the

few user diaries the site has received so far) my politically-oriented goals for engagement fall short of being met. Then again, since the model I'm working in is open-ended emergent engagement, users are equally welcome to participate or resist participation once they enter the site, and their lack of engagement so far may be reflective of an emergent model being met.

My need to care for – and at times prioritize - the scholarly writing about my practice may be partly responsible for the ways I neglected care from its actual functioning as an engagement project. At the same time, it ironically also gave me the justification to not care for the audience engagement dimension of the project, since my research questions are focused on the *engagement event production process* and not the *public uptake of the engagement event.* Perhaps if I had different research questions, this story would be different. Nevertheless, my case study demonstrates the shaky grounds for greatness that practice-based research can create due to the multiple competing demands of carrying out multiple competing roles. One of the things I've learned is that it is possible to make a practice-based PhD's practical output (such as Aurator) so vulnerable to the scholarly demands of the thesis that it fails to succeed as a media project all on its own. Therefore, the practice-based outcome requires being identified at all times as a hybrid aspect of a larger practice-based academic research project in order to recognize its success.

My learning highlights the importance of hybridity to the theoretical discussions around what constitutes knowledge production within practice-based research. Pakes (2004) asks, "Is new knowledge generated in the process of making, and then made manifest and shared through the verbal reflection on that process? Or do the artistic outcomes of that process – the artefacts created – have epistemological primacy as the embodiment of new insight?" From my experiences, I would argue that the answer is neither of those options. The research and practice are highly substantive of each other in terms of the knowledge they produce, and they must be absorbed as a hybrid entity in order for their value as

knowledge to be absorbed. Otherwise, either half of the project, be it the scholarly writing or the practice-based output, may be vulnerable to failure in terms of what they can teach us.

Although I feel confident that I met my formal and aesthetic goals for Aurator, those goals were based on the paradox of *planning for unpredictable emergence* - a contradiction in terms. I briefly discussed how this is problematic in my methodology chapter, as it is difficult to see how one can *plan* for something that will have zero constraints or eventual parameters, which is by nature able to evolve any which way. Emergence and open-endedness become instrumentalized when they are planned for, and as such may not ever be able to be genuinely achieved. This reminds me of Wynne's argument about the futility of scientific institutions that try and convince publics to trust science through engagement events because there is a fallacy in the idea that institutions can instrumentalize public engagement while deceiving themselves that they are actually listening to publics. "It is a contradiction in terms to instrumentalize a relationship which is supposed to be based on trust." (Wynne 2006: 219). Similarly, it is a contradiction in terms to *plan* or *design* for emergence in engagement formats while deceiving yourself that what you are doing is creating genuinely emergent and open-ended experiences that are not shaped by any prescribed factors. In reality, there are always premises set up by the engagement event producer that will have an influence on what kinds of engagement may flow forth from the design of that engagement event's script, format, forum, questions asked, participants invited, topics highlighted, phenomena ignored, etc. Accounting for these influences and limitations then becomes the job of the reflexive researcher-practitioner.

This brings me to reaffirm another great affordance of the practice-based PhD: it teaches practitioners *how to be reflexive* about the kind of work that they are already busy doing. Although the process of becoming reflexive about one's craft requires time, intellectual strain and the ongoing realization of having not yet caught all of one's blind spots about what they are doing and how they are doing it, the reflexive way of doing practice – to the degree that it is demanded in a PhD by practice - is skipped over in

most normative industrial media production settings. But a practitioner will gain this wonderful learning experience by doing a practice-based PhD, and that is enough of a benefit, to my mind, to justify undertaking one at all. If one doesn't plan to stay in academia, like myself, the challenge then is to continue practicing this reflexivity in future productions. This burden of self-enforced reflexive practice in industrial media settings is an interesting area that future research could investigate: how does the experience of completing a practice-based PhD shape the way a practitioner carries out their future work outside of the university, if it does at all?

Personally, I believe that the trade-offs involved in a PhD by practice are not threatening enough in either domain (as a researcher or as a practitioner) to make it not worth doing. On the contrary, the trade-offs are opportunities: experiences that make one more sensitized to the particular requirements of their work that they may have not been consciously aware of before. It is an exceptional format for learning by experimentation that forces one to confront the limits of their research and practice. It is at once a frustrating, humbling and satisfying way to nourish one's multiple interests, which is well worth advocating for the opportunity to do in the academic sphere.

The limits of engagement: how critical can one be?"

Aside from the limitations of practice-based research already mentioned, I am interested in an additional set of limitations that were created by the structural aspects of this public engagement project. I have made many arguments throughout this dissertation in support of having open, emergent engagement fora to discuss matters of interest and concern in synthetic biology. I even produced Aurator as a digital forum for this kind of engagement to take place in. Yet, my PhD research was substantially funded by BioSYNergy - an interdisciplinary research network at the University of Copenhagen that is focused on the advancement of innovation in plant synthetic biology. The job announcement for my PhD

position described the BioSYNergy project as such: "The project explores how synthetic biology, particularly with relation to plants, can be used to cheaply and sustainably produce compounds such as pharmaceuticals. The project incorporates a bioethics and communications platform for dialogue with society on the use and implications of synthetic biology."[27] This reads rather formulaically as a description that could fit many kinds of interdisciplinary knowledge networks in synthetic biology that aim to advance the science, putting other scholarly investigations, such as bioethics and communications, second. The attention the BioSYNergy research framework gives to ethics and public engagement activities is more of a tacked-on appendage than a central theme; a model that's replicated in other interdisciplinary networks (e.g. Rabinow and Bennet 2012, Balmer 2012, Balmer et al. 2016).

It would seem that my research network is vulnerable to the same kinds of critiques that would claim it is interested in performing its responsibility through scholarly engagements with other disciplines, just as Marris has shown most "synbiophobia-phobic" efforts desire to appear to be doing. This performativity of responsibility is key. To wit, throughout my three years of study at the university, I hardly met with any of the synthetic biologists (beyond my research participants), legal scholars or bioethicists in the BioSYNergy network. I did meet with my supervisors regularly to discuss what our type of media scholarship in this network might be able to do, but over the three years of study, I treaded very lightly across disciplinary divides in the network. There was no centralized framework that invited us to regularly share and discuss our research with each other, which presumably would have been required in order to foster new knowledge in the network through interdisciplinary collaboration and critique. I did once go to a network committee meeting that was mainly attended by principal investigators from the

[27]Science Communication with a focus on Synthetic Biology PhD (Re-announcement), University of Copenhagen, Faculty of Humanities, Department of Media, Cognition and Communication. June 27 2013.

various involved disciplines, but I was surprised to see that no other PhD students or post-docs from the network were there to share their research. A few coffee meetings were arranged with junior researchers from the other disciplines in the network at the beginning of my studies, but these quickly disappeared as people entered and left the network, and we all pushed forth in our individual projects without a centralized structure for sharing knowledge between us.

There may have been other opportunities to share ideas with one another that I missed out on or didn't hear about, but the general experience of researching in BioSYNergy was a significantly solitary one for me. Most notably, the interdisciplinary aspect of our knowledge network exists on paper but not in the lab, office, or field. It indeed would seem that it performs itself as an interdisciplinary network to appeal to external bodies such as funders, which our research activities are reported to. I do not think that the paucity of cross-disciplinary collaboration is due to anyone's poor intentions, resistance to the theories and policies that underpin it or laziness, but more likely because everyone is too busy doing what they already have to do: running a lab, looking after students, publishing research, etc. However, by describing our activities every now and then to the network, BioSYNergy can "tick the box" on its funding reports that the various desirable interdisciplinary activities have been undertaken. As Hagen points out (2014), this creates an impression of responsible research and innovation, though few researchers in the network have any idea of what each other are doing across our disciplinary silos.

It would seem then that my work is also vulnerable, just like the ELSI researchers, artists and designers, to becoming a tool that supports the field's performance of its own responsibility and thus public acceptability. If the presence of a practitioner like me in an interdisciplinary research network is more performative than it is material, public engagement practitioners have just as much to reflect on - in terms of their limitations for critical effectiveness - as the ELSI researchers, artists and designers that others have written about.

Therefore, I must similarly question the effects of my work as an engagement event producer. I am not sure what Aurator's effect on people has been so far, or what it will be in the future. Perhaps its mode of engagement will be able to foster new insights, criticisms and arguments about the field, though it may just lure people into thinking that synthetic biology is a mature and self-reflective field worth thinking about. Is Aurator a "pseudo forum for synthetic biology" as the chimpanzees of the future (written about in chapter two) might say? I can see how it runs the risk of being one, with its sleek aesthetics, lack of navigational direction, paucity of a call to action, funding structure and connection to a synthetic biology network that declared it will "incorporate a bioethics and communications platform for dialogue with society on the use and implications of synthetic biology."[28] Those who are criticized as being cogs in the wheel of public acceptance, such as public engagement event producers, should "develop complex and flexible types of responses toward criticisms" (Meyer 2017: 131). I believe that the PhD by practice teaches one to develop sensibilities for dealing with these kinds of criticisms flexibly and productively. The best an engagement practitioner may be able to do is care enough to face up to these criticisms, analyze their own role in validating or challenging them, and respond by explicitly acknowledging their communication goals and how they become vulnerable to competing tensions at various steps of the way.

Caring for knowledge production in science

Care is a loaded word that can be interpreted in many ways. It is both the stuff of everyday relations with the objects, non-human, and human creatures that fill our lives and the deliberate strategic acts of making social existence better along multiple planes. It is simultaneously necessary and voluntary;

[28] Science Communication with a focus on Synthetic Biology PhD (Re-announcement), University of Copenhagen, Faculty of Humanities, Department of Media, Cognition and Communication. June 27 2013.

given and received; sometimes it is missing, and sometimes it is too much. Fisher and Tronto define it as "a species activity that includes everything that we do to maintain, continue, and repair our 'world' so that we can live in it as well as possible. That world includes our bodies, ourselves, and our environment, all of which we seek to interweave in a complex, life-sustaining web." (1990: 103). Others have questioned this prioritizing of human agency as the starting point for any practice of care. Instead, they argue for a post-human understanding of care across all forms of life that do not follow a human-centred understanding of the concept, but extend the ability to care and be cared for to non-human lives and objects (e.g. de la Bellacassa 2017, Kirksey 2015, van Dooren 2014).

Feminist scholarship has concerned itself with a feminist politics of care, born from an interest in the types of care women and other marginalized, historically oppressed groups have been socially expected to provide for a variety of aspects of daily life, while their labour has long been de-valued. This invisibility of care, and how technologies continue to render female and marginalized people's labour as something to take for granted, has inspired the work of several feminist STS scholars. For example, Lucy Suchman's critique of "smart technologies" has shown how the efforts to demonstrate the agency of "assistive technologies" to the "service economy," make critical assumptions about whose interests they should be serving as they de-value domestic work and mask the complex forms of human labour that go into making the devices possible (Suchman 2007). Although "smart" interfaces in software for "assistive technologies" can be said to provide care to the consumers they are assisting, Suchman demonstrates how they undercut care to certain populations, and in particular labourers, in their design and use. She asks, "what kind of social relations are assumed to be desirable … whose interests are represented, and whose labours are erased?" (2007: 224). In this sense, care is not something that appears in a system at some moment and forever thereafter will exist in that system, rather it is an interwoven fabric of provision for some and neglect for others. The fabric of this negotiation, in its asymmetry, is something that can be re-

imagined and re-assembled. A feminist ethics of care, in other words, recognizes that care is a dynamic process full of ambivalences, not a singular monolithic thing. Speaking to this quality of care that involves constant change, Puig de la Bellacassa writes, "A feminist ethos of representing care is not reduced to the application of an established theory but it has to be constantly rethought, contested and enriched." (2011: 96).

Feminist sociologist of science Hilary Rose, whose work has contested the boundaries of nature and culture laid down by sociobiology, has argued that, "caring demands empathy and affection which honour the autonomy of the cared-for, effective support demands complex practical and emotional labour, skills developed actively through the carer's lives." (1994: 49). Writing about Jane Goodall's deep empathy for chimpanzees and Barbara McClintock's love of her organism, maize, Rose points out that emotions are always needed in order to arrive at nonviolent understandings of the world when one is producing new scientific knowledge. She urges us to do science with love, and to practice it with care: "Where Bacon's origin story for science spoke of the intimate connection of knowledge and power, the feminist critique of science, from Mary Shelly onward, has spoken of the danger of knowledge without love." (1994: 50).

Mary Shelley's Frankenstein explores the unintended consequences of human science when we relinquish responsibility for what we create. The full title of the book is Frankenstein, or The Modern Prometheus. In Greek mythology, Prometheus taught humans how to make fire, which he stole from the gods, and was punished for by Zeus, who sent birds to eat his entrails. The myth underscores the idea that there are some things that only God should know. Isaac Asimov, the science fiction writer, aptly coined the term "Frankenstein complex," meaning the fear of encroaching on God's terrain through technology (1978). As a case in point, when people fear genetically modified foods, they sometimes call them

"Frankenfoods."[29]

But for how often Frankenstein is referenced, people don't usually recognize the real moral of the story. We don't tend to remember that Frankenstein was the name not of the monster but of the doctor who created him. In the more than thirty film adaptations that have been made of Frankenstein, audiences always see the monster's malevolence, but in the novel the monster only becomes evil later on. "Remember that I am thy creature," it moans. "I ought to be thy Adam; but I am rather the fallen angel, whom thou drivest from joy for no misdeed." (1999 reprint of 1818 text, ch. 10, pg. 3). The monster transforms into something uncontrollable only after Dr. Frankenstein abandons it, horrified at what he's created, and refuses to deal with the consequences of his own actions. The monster even protests his misfortune and says, "I was benevolent and good; misery made me a fiend. Make me happy, and I shall again be virtuous." (Ibid.) So the story does not actually suggest that there are some things only God should know. Rather, it shows us why we have to take responsibility for what we have created. This is why the anthropologist and philosopher of science, Bruno Latour, argues that the real lesson Frankenstein has to offer is that we must love and care for our monsters so that they do not turn mean (2015). But he does not imply that we should avoid creating them altogether. In other words, the act of caring is a necessary aspect of responsible science, and we ought to recognize it as such.

Caring for science communication

As I have explained, a variety of thinkers have argued for the necessity of care in science, and I have built on that foundation in this thesis, through my study of the function of emotions and affects in science communication, to demonstrate why we must also ensure that emergent forms of care are present

[29] Some of this writing about Frankenstein appears in my book *Rise of the Necrofauna: The Science, Ethics and Risks of De-Extinction* (2017, Greystone Books).

in our public engagement projects about science. Emergent forms of care are dynamic, flexible, and responsive to what happens over time between different actors in a system, and by virtue of its dynamic properties it also carries asymmetries with it that sometimes value care for one aspect of the system over others. On the topic of asymmetry in care, Martin et al. write, "Care is an affectively charged and selective mode of attention that directs action, affection, or concern at something, and in effect, it draws attention away from other things…Given the asymmetrical power relations that care can set in motion, it must be enacted carefully: care's partialities, limits, and effects must be located, situated and questioned." (2015: 635). It therefore is crucial to ask: who has the power to care? Who sets caring relations into motion? And who defines how it can take place? In my experience, I have discovered that the science engagement event producer bears the majority of this role's responsibility, although every agent involved plays a part. In my research, I have approached the politics of care from a distinct vantage point as the engagement event producer, bearing the brunt of this responsibility, in the context of an audio diary project that creates the opportunity for interactive online engagement. The particular context in which this research took place necessarily brings with it specificities about how care is interpreted and practiced that relate to the individual communicating experts involved and the media used. However, there are generalizable lessons from this study that can be extrapolated and offered to science communication practitioners on the whole.

In this study, I researched factors that cause communicating experts to inscribe (add) new modes of participation into communication activities they are invited into by the engagement event producer; and factors that cause communicative experts to de-scribe (resist or withdraw) their participation from the event, leading to its breakdown. Taken together, these factors were studied through the lens of emotional and affective phenomena, which demonstrate how such phenomena can shape the overall outcomes of engagement and the science communication therein, long before publics even appear in the emergent system of an engagement event to interact with it. Themes that emerged from the pre-project

interviews I conducted with the communicating experts demonstrated a variety of factors that caused them to accept the script of participation that I invited them to partake in through the audio diary solicitation process. These included: curiosity about the novelty or "coolness" of the methods; perceived usefulness of the communication experience for the diarist's own work (such as learning new methods and research skillsets through exposure to my research methods); the ability for participation to reinforce what the communicating expert is already busy doing with their work, such as promoting polyphony in a Bakhtinian sense in the discourse on synthetic biology; the opportunity to act on one's self-identification as a science communicator (Baram-Tsabari and Lewenstein 2017); and the hope to become a "visible scientist" (Goodell 1977) who may be able to *move* or *affect* others by communicating publicly about their science. My findings also show how a communicative experts' engagement in the project was shaped by her or his perceptions of the audience they were speaking to (and their expectations of who those disembodied future audiences might be), as well as the durational properties (the expanses of time) they used for their participation.

However, I also discovered a variety of ways in which the emotions and affects experienced by event producer, rather than those of the communicating experts, shape the final outcomes of engagement (again, long before publics appear to interact with the engagement event). These include my feelings of having been moved and affected (or not) by science communication content, which directly determined whether that diary's content was accepted and added into Aurator or not, as well as my perception of the diarists' own performance (and ability) of being a science communicator. I also analysed the growing pressure I felt to *simply produce* after a certain point in order to deliver on engagement promises I had made and the care I felt for the engagement event to exist at all. This pressure put me in a position where I then had to compromise between competing forms of care for my engagement project: genuine and honest intellectual care versus funding care. Then there are also the various ethical responsibilities that emerge

throughout the production process that are underpinned by emotions and affects that arise in interactions between the communicating experts and the event producer while science communication is being collaboratively made.

Science communication scholarship is accustomed to focusing on the emotional and affective experiences of publics that interact with science engagement projects, which is evidenced by the healthy and growing literature on publics' perceptions of museum visits, exhibitions, debates, citizen juries, science festivals, slams, and more (e.g. Anderson and Lucas 1997, Myers et al. 2012, Avellaneda et al 2016, Lowndes et al. 2001, Gaskell et al. 2000, Roeser 2012, Kerbe and Schmidt 2013). In the growing sub-field of "the science of science communication," scholars interrogate the cognitive biases and values different publics arrive to a scientific debate with, in order to understand how their biases and values affect what types of (often heated or emotional) communication takes place about polarizing topics, such as vaccines, genetically modified organisms or climate change (Mandel et al., 2013, Kahan 2013, Kahan 2010, Kahan et al. 2009). What my project shows instead is that science communication scholars and practitioners also need to be thinking about how to care for the experiences of communicating experts and the engagement event producer, before any publics appear, in order to truly account for how emotions and affects shape science communication. As it is now, scholarly focus is on the emotional and affective perceptions of publics after they engage at an engagement event, but my findings suggest that these types of emotional and affective phenomena are shaping science communication long before publics' perceptions can even be studied. Rather, they're shaping science communication from the very second a project's design begins, the participants are invited, and the communications that constitute their participation get made.

Marks and Russell have argued the case for acknowledging care in public engagement settings, and describe the role of engagement practitioners as already involving practices of care due to the various ways they pay attention to diverse publics and try to accommodate their needs when creating safe

spaces for deliberation and reflection in multi-stakeholder discussions about science and technology (2015). The very attempt to create a space for engagement, seen this way, is an act of care. The fact that I created Aurator – with an objective to assemble voices with different viewpoints about synthetic biology - is therefore an act of care under their interpretation. They write "Care can work to assemble people and perspectives, open up normative issues and potentially build reflexivity in us … as well as in those we bring together. (Marks and Russell 2015: 111). They rightly describe the implicit care (for the world, for society, for science) involved in assembling different points of view in a forum for open-ended discussions, as well as attending to different perspectives' needs in engagement events. However, this description of care in public engagement does not quite go far enough. The practice of care is not only something that engagement practitioners are already doing in engagement settings, it is something that engagement practitioners must become explicitly aware of as a tool for their work. They should develop a sensitivity towards the needs for different forms of care that will emerge differently at differing times throughout the engagement process. Furthermore, an explicit practice of care in science communication understands that a practitioner may have to jeopardize care for some aspects of engagement while privileging care for others in order to make engagement happen in an imperfect but pragmatic way. As my case study of making Aurator shows, we must ask ourselves which kinds of care we are comfortable with putting ahead of others in order to do our work. This can be an uncomfortable truth of the trade, generating its own affects and emotions for the practitioner, such as the compromised feelings I developed by experiencing *the pressure to produce,* where I had to endanger some of my intellectual integrity for funding. A related example being how the conditions of practice-based research introduce their own limitations (in terms of resources and time), which meant that I could produce Aurator successfully to a certain degree, but neglect its connection to publics who would actually use it.

A variety of instances appear in this thesis that demonstrate the need for an ethics of care, for which the event producer may be able to provide their attention to shifting and compromising forms of care that are needed to run an engagement project as ethically as possible. For instance, the insider status of the event producer, who inhabits mixed roles as researcher, editor, and storyteller representing the communicating experts in the event's final outcome requires special attention. In the context of audio diary methods, Worth has argued that this set of mixed roles requires its own special type of care: "This insider status needs careful attention…the status of the researcher, and the positioning of the audio diary as a solicited research product complicate the relationship of participant as audio diarist and researcher as listener." (2009: 13). This mixed role also brings with it "response-ability." "Response-ability encourages a practice of making oneself available to respond without knowing ahead of time which phenomena will call one's attention or what form the response should take." (Martin et al. 2015: 635). For example, although my role as engagement event producer and researcher was central to how the communicating experts related to me and cooperated with the goals of the project, when the social scientist (to my complete surprise) asked me to remove a substantial amount of her diaries from Aurator due to her own feelings of discomfort, it would not have been ethical to prioritize my role as event producer and researcher (which may have involved exercising my right to use all of her diaries as my research consent form protected me to). Instead, the situation called upon me to be "response-able" to her request through an ethics of care, where I was able to react to her emergent and unpredictable state of experience. This "response-ability" responded directly to emotional and affective phenomena she was experiencing, and compromised the types of care I was able to administer: care for my project versus care for my participant, though of course caring for my participant becomes, on the whole, another way of caring for my project's outcomes that is different from what it would have been had I just retained all of her diaries on Aurator. It is only one of

several instances in this thesis that demonstrates how *emotion* and *affect* function and how *care matters* in the way that science communication gets made.

Another instance appears in my discovery that the event producer is particularly vulnerable to a variety of affects throughout the preparation, fund-raising, design, production and execution of the engagement event that could change its overall way of performing itself (for example, in its marketing) and even distance the project from its own original goals. My encounter with the synthetic biology institution's director and board of directors demonstrates how I responded to the pressure I was feeling to deliver on my engagement promises through a tenuous form of care that, similarly to the example above, provided care for one aspect of the project while removing it from another. In order to collaborate with the institution and receive their funding which would allow me to produce the engagement event, I had to communicate differently about the motives, goals, and abilities of the outcomes of engagement, before I had any evidence to show the project could even deliver on those promises. Meanwhile, the way I was shifting my language to describe the project (in order to appease the institution) trespassed against some of my original research goals and theoretical frameworks. In this situation, I had to administer a hierarchy of care. At that time, I decided to administer more care for the needs of the institution and my growing feelings of being affected by the pressure to produce Aurator, than I did care for the original theoretical principles of the engagement event itself. The moment at which I compromised the ideas that frame the engagement event and form part of its methodology, and begin to work against the critique that a scientific institution can never instrumentalize engagement to build trust with its publics, that becomes an active site of ambivalent, shifting and dynamic care provision. For if I had not done this, I cannot be sure that I would have been able to create Aurator at all, and that concern decided what types of care could be compromised. Therefore, due to the emergent nature of emotions and affects that appear throughout a dynamic engagement production process, the concept I am introducing here of *caring for science communication*

may require slipping away from pre-configured ideals of holistic care in order provide asymmetrical forms of care that are required to make other basic elements of the engagement event function. Mol et al. describe this kind of negotiation as the process of finding "good enough" care.

> "On the ambiguity of care, and the fact that it should be 'good enough.' Good and bad may be intertwined; good intentions may have bad effects; if one looks hard enough any particular 'good' practice may hold something 'bad' inside it (and vice versa); 'good enough' care may be a wiser goal than care that is 'ever better'; while sometimes it is simply unclear whether (for whom, to what extent, in which way) some form of care deserves to be praised or to be criticized." (2010: 13).

Sometimes care was implicitly present in the engagement event's design, though I was unaware of it. For example, the biohacker expressed the importance of feeling that no matter what he recorded, there would be at least one person in the world (the event producer) who would listen and care about what he had to say. The fact that I would be listening as that one person who cared, motivated him to participate. That feeling of being cared for by a "science therapist" as he described it, created a safe space that he otherwise did not feel he had access to in fora where talking about science is normative. It gave him a venue to communicate "crazy ideas" that he otherwise would have kept bottled in. In this sense, public engagement practitioners would do well to consider how they are administering an ethics of care in the very design of their science communication projects and modes of participation according to the specific methods they use before communicating experts are even invited to accept their script for participation. These types of considerations, based on an analysis of care, could have strong impacts on their participants' agreement to participate or withdrawal from participating as expected in a project, directly shaping the overall project that publics will later engage with.

Futhermore, based on my encounter with the watchdog that resulted in his total disappearance from the project, I would also urge engagement event producers to be *careful* when assessing the expectations of communicating experts in terms of how they perceive their own role as science

communicators and participants. The personal feelings held by communicating experts about their ability to communicate science may be less developed than the engagement producer anticipates or assumes. Although science communication may not seem like the most nor least obvious place to consider the fragility of egos and confidence for how one assesses their own abilities, these considerations and sensitivities should be treated with a great deal of care.

After taking stock of this audio diary project and my mixed role as a researcher, practitioner/producer, and my own research subject, which calls for many different forms of ethical "response-ability" by *caring for science communication*, I have discovered that care has no end goal or arrival point, but can be practiced emergently alongside the emergence of the engagement event itself. It is a practice of attentiveness and is totally unpredictable. As such, is a form of experimental research as Roepstorff and Frith have described it:

> "Experimental research is, it is increasingly clear, a complicated practice, a bricolage tinkering with the possible elements to make things work. In the everyday reality of lab work, the ideal experiment to end all experiments and settle discussions once and for all seems usually a utopian dream. In reality, it only seems to exist in hind sight, in that painful realization that only after one has struggled to create some facts from the usually somewhat messy data does one know how one should really have constructed the experiment…As tales from the field tell again and again, it is usually a matter of frustration, of uncooperative or over-cooperative informants who follow their own agendas, of loneliness, boredom, of making the most of those events, which suddenly occur." (2012: 103).

The difficulties of the experimental nature of research that allow us to understand in hindsight how it could have always been done better or differently, necessarily call upon engagement event producers to employ an ethics of care in their work. This ethics of care is an unstable process, not a steady state, and its iterative nature leads us to learn, design, carry out, and follow up with the engagement events we are responsible for, in the most "response-able" ways we can.

This notion of experimentation directly ties in with how Mol et al. describe care as a tinkering practice. They write,

> "care implies a negotiation about how different goods might coexist in a given, specific, local practice…seeking a compromise between different 'goods' does not necessarily depend on talk, but can also be a matter of practical tinkering, of attentive experimentation. In care, then, 'qualification' does not precede practices, but forms a part of them. The good is not something to pass a judgement on, in general terms and from the outside, but something to do, in practice, as care goes on." (2010: 13).

Understanding care as a tinkering practice, which is free from uniform judgments about what kinds of care are better than others, searches for "good enough" care, rather than an absolute form of it. By experimentally tinkering and working one's way forward in an engagement event's production, a producer is able to touch on and experimentally test out approaches to ethical care that may simply be "good enough" to respond "response-ably" to whatever is happening at a particular moment in time. Science communication requires this of us, because as this thesis has demonstrated, at all points in the process of creating a science engagement event (from design and planning to execution) communicating experts, the event producer, and more generally – people – are vulnerable to myriad unpredictable affects and emotions that directly shape the outcomes of engagement. These affects and emotions call on us to accommodate them in flexible ways. Most notably, it is the engagement event producer who bears the burden of making these accommodations, who must also navigate decisions about how to make them ethically despite the asymmetrical nature of how care functions across different competing demands. It remains to be seen how this burden functions in the "everyday" world of science communication for other engagement practitioners, but I argue that practitioners should be mindful of this insight. Finally, affects and emotions vibrantly reveal material tensions in engagement projects, and at all times, deserve to be responded to response-ably with an ethics of *caring for science communication.*

Conclusion

In this study, I employed practice-based research rooted in interactive documentary and audio diary methods to investigate the function of emotion and affect in science communication. I studied how emotions and affects shape the way that communicating experts take up, resist and transform their roles as participants in a public engagement event and concluded that these phenomena directly shape the process of participation and communication it produces in several ways. I also investigated how the emotions and affects that I experienced as the producer of the engagement event shaped the event and its eventual communication products.

The scientific field that I have examined in this dissertation is synthetic biology, a field that has been criticized as being particularly vulnerable to instrumental approaches to public engagement that aim to engineer public acceptance of its practices based on a pre-existing fear that publics will not accept it (Marris 2014, Hagen 2016). Public engagement efforts that try to ensure that publics will trust scientists before they have even engaged with them are not examples of public engagement that is open and free from intended outcomes as described by Horst and Michael's emergence model of science communication, which framed this research. It is futile for institutions to try and instrumentally engender public trust in science because scientific institutions that try to appear trustworthy through public engagement "hit the notes but miss the music" (Wynne 2006). What is more worthwhile for scientific institutions to spend their time and energy on when engaging with publics is to try and improve their own *trustworthiness* rather than focus on how to most effectively convince publics to trust them. Brown and Michael argue one way that such trustworthiness may be built and demonstrated is through emotional engagement that reveals the affective discomfort of opening a scientific institution up to public scrutiny and diverse viewpoints (Brown and Michael 2002).

Considering synthetic biology's vulnerability to synbiophobia-phobic forms of public engagement (Marris 2014), I searched for science communication tools and theories that would allow me, as a practitioner, to create a space where communicating experts who work with synthetic biology could demonstrate their intimate thoughts and feelings about the field in an emergent fashion that resists instrumentalization. In order to this this, I worked with a model of science communication that is not prescriptive in terms of what people will get out of the engagement event (such as "more knowledge" as the deficit model would expect publics to receive, or "mutual understanding" as dialogic models of communication would describe). I therefore framed this study using Horst and Michael's emergence model of public engagement (2011), which explicitly characterizes how non-prescribed engagement events can take place. Importantly, it is also a model that is open to emotions and other non-discursive elements of communication being substantive of engagement processes and events. Using Horst and Michael's emergence model, I created an engagement event about synthetic biology that offered participatory roles (the "script") to a multi-disciplinary group of communicating experts working in synthetic biology.

In particular, I put the emergence model of science communication into use by choosing methods that aim for the "unfinalizability" of engagement about synthetic biology. I employed the term in the way that the 20th century Russian literary critic Mikhail Bakhtin used it to describe the phenomenon of "multi-voicedness." Bakhtin extensively studied the novels of the Russian author Fyodor Dostoyevsky, which he saw as influenced by many diverse, conflicting forces based on the interests of multiple individuals. To explain this, Bakhtin coined a new term – "polyphony" – which describes the signature narrative form that Dostoevsky used in his characters' dialogues. Polyphony is based upon a premise of multivoicedness, and describes Dosteovsky's tendency to write novels in which his characters would each speak for themselves and not speak in the service of any other character's agenda.

I operationalized the concept of "polyphony" with an intimate form of diary methods known

as audio diaries. I solicited audio diaries from a group of multi-disciplinary communicating experts who keep track of their feelings and thoughts about synthetic biology in self-made audio recordings that responded to prompts I sent them once a week over a twelve-week period. This group included: a synthetic biologist, a bioethicist, an artist, a sociologist, a spokesperson for a watchdog group, a biohacker, and an entrepreneur. The footage from their audio diaries was used in order to make Aurator - an interactive online audio archive about synthetic biology that falls into the media format category of "i-docs". I-docs "chang(e) users into co-producers and creat(e) a dynamic of co-responsibility and polyphony towards the reality that is portrayed by the documentary." (Gaudenzi 2013: 36). In this sense, the participatory i-doc provides a digital interface where polyphony can take place. Aurator brings the communicating experts' diverse perspectives into conversation with each other in a way that allows publics to engage with them in unfinalizable, polyphonic and heteroglossic fashion.

The data generated in my pre- and post-project interviews as well as the diary solicitation process allowed me to study the role emotion and affect had on the science communication the communicating experts' produced, my production choices as a practitioner, as well as the overall outcomes of the engagement production process. I analysed these data to answer two research questions that follow.

1. How do the emotions and affects experienced by communicating experts in science engagement productions that publics will eventually engage with, shape how they inhabit their roles as participants?

2. How do the emotions and affects experienced by the public engagement practitioner (the producer of the engagement event) shape the outcome of the engagement event?

In order to answer these questions, I used Felt and Fochler's concept of "machineries for making publics" as an analytical framework (2010). I adapted this framework in order to detect "machineries for making communicating experts" so that I could investigate how emotion and affect influenced their participation in the engagement event as communicating experts. According to Felt and Fochler, machineries for making publics are the processes by which publics come to inhabit their roles as engaged participants in different ways, which they argue, can be understood by using Akrich's 1992 study of how designers imagine an object and how it will be used when they "inscribe" their vision of the world in the physical design of the object. Once the object is "inscribed", certain forms of its use inherently become "prescribed", which some users may comply with, however others may engage with the object against the grain of the designers' imaginative "prescription" for how it should be used. When this happens, the object gets "de-scribed" by the users' subversion of the designer's vision and framing for the object's use. However, where Felt and Fochler's work concentrates on how members of the public accept, resist, or transform their roles as participants in engagement events, I focused instead on how experts, such as an entrepreneur who is embedded in the synthetic biology field accepts, resists or transforms his role as a communicating expert in a public engagement event.

My analysis of the pre- and post-project interviews, as well as the audio diaries themselves and my research journal data yielded several findings pertaining to my two research questions. When I was looking to answer my first research question about the function of emotions and affects experienced by communicating experts during the public engagement event, I discovered patterns that caused the them to accept the script of participation that was offered to them, as well as to add new modes of participation into their communication activities. Patterns also emerged around factors that caused the communicating experts to resist or reject their participation, leading to its breakdown. Emergent themes demonstrate a diversity of factors that caused them to accept the script. These included: curiosity about the novelty or

"coolness" of the methods; perceived usefulness of the communication experience for the diarist's own work (such as learning new methods and research skillsets through exposure to my research methods); the ability for the "script" to reinforce what the communicating expert is already busy doing with their work, such as promoting polyphony in a Bakhtinian sense in the discourse on synthetic biology; the opportunity to act on one's self-identification as a science communicator (Baram-Tsabari and Lewenstein 2017); and the hope to become a "visible scientist" (Goodell 1977) who may *move* or *affect* others by communicating publicly about science.

Furthermore, my analysis revealed that communicating experts may add new meaning or function to their participation that was not originally offered to them if they feel particularly cared for during the engagement process (such as the biohacker's perception of me as a "science therapist"), and if they see their participation as an opportunity to act on their own pre-existing self-identification as a science communicator (Baram-Tsabari and Lewenstein 2017). Patterns also emerged from the data that indicated factors that may cause communicating experts to resist or altogether stop participating. These patterns all related either to instances when the event producer assumes something about the engagement capacities and interests of a communicating expert, or the burden of the mode of engagement itself. Sometimes when I inscribed my own feelings and assumptions about participation into my expectations of the communicating experts, their participation completely broke down. For example, the type of care that I demonstrated to the biohacker that allowed him to feel safe and secure enough in my presence to add a wealth of unpredictable participation to the project as I became his "science therapist," was the same expression of care I showed the watchdog, which led to his complete disappearance from the project. Care is therefore not a quality that is inherently possessed by the public engagement producer or that will affect all of the communicating experts they work with in the same way (Mol et al. 2010). These findings suggest

that engagement event producers should develop an awareness of and ability to negotiate the performative nature of care in science communication, which I will revisit.

I have also analysed how the material dimensions of the audience can generate feelings and affects in public engagement events that shape communicating experts' participation. Audience operates in multiple states at once. It is both an expected, imagined phenomenon that is always present as a disembodied idea during the preparation of an engagement project, and a material, physical phenomenon when real members of the audience get access to the engagement event (in the case of this research, internet users). I found that perceptions of these multiple states of audience create different emotions and affects for communicating experts that can affect the way they accept or resist the script they're offered as an engagement participant. Therefore, public engagement practitioners should be attentive to their communicating experts in order to not, for example, foolishly take for granted that bestowing one's participants with a device that allows them to record themselves intimately, privately, and autonomously, will necessarily produce an archive of fully authentically performed selves. They may be performing to accommodate a variety of imagined or material audiences; performances that differ one from the next according to the power relations between the various audiences and themselves, and that differ according to the expert's own self-identification as a visible science communicator.

Furthermore, my findings show that communicating experts may take very well to intimate engagement methods and be very keen to accept the script or even add new functions to it, but their high adoption rate of the intimate methods does not mean that they have reflected on what might be at stake for them in the future once the engagement event is public and they are no longer entranced by the rhythms of engagement (for example: recording). They may feel surprised, concerned, embarrassed, vulnerable, or ashamed to discover what they once revealed, long after the fact. Therefore, there are several ethical issues involved with using intimate, durational methods for emergent engagement that call upon

producers to *care for science communication,* in the way that this thesis describes it.

When I set out to answer my second research question about the function of emotions and affects that are experienced by the public engagement practitioner and how that shapes an engagement event, three main findings emerged. Firstly, I discovered that my decision to reject a diary was influenced heavily by how the diarists' performance as a diarist affected me. For example, if their diary was poorly recorded and therefore sounded bad, or if it was meandering and incoherent or off-topic, it got rejected. Additionally, a factor that helped me determine whether a diary was good to add was my impression of the communicating experts' self-concept as a science communicator, based on what they said in their recording and importantly, how they said it. Therefore, the material conditions of their performance as science communicators affected what happened to their diaries when the engagement producer became involved as an editor. Secondly, my production decisions were largely driven by the pressure I felt to *simply produce* the engagement event, which grew over time, directly shaping Aurator's outcomes. Thirdly, decisions were shaped by my own ethical responsibilities, which called upon me to develop a practice that I call *caring for science communication.* My discovery of this practice was led by the emotions and affects I experienced as co-constructions between the communicating experts and myself.

When making Aurator, it was a conscious production decision to include audio clips from the diaries that moved me, but their ability to move me was not voluntary. Rather it was something that would happen or not, in an intuitive and affecting fashion. There were many factors that caused me to not select an audio diary excerpt for use in Aurator, ranging from poor technical recording, to meandering incoherent thoughts, to off-topic speech and more. However, in all cases, a constant factor that helped me determine whether a diary was good to add was my impression of the communicating experts' self-concept as a science communicator, based on what they said in their recording and importantly, the way in which they said it.

Furthermore, the emotional and affecting pressures I felt to succeed in producing the engagement event influenced the way I marketed and sold the idea of Aurator to funders in order to make it possible, which had a direct effect on the final engagement project, and necessitated caring for certain aspects of the project over others. I also analysed the ethical dimensions of my role as someone who makes decisions about how to represent the communicating experts' diaries through the media production process. I used Howard Becker's concept of "the morality of representation" in his book *Telling About Society* (2007) as a way to analyse how my role as a "maker" has ethical implications when editing, adding and rejecting the recordings of my diarists for Aurator's public-facing production. My analysis yields a set of instances where the event producer must try to negotiate the necessary ethics of care when doing engagement, according to a dynamic, emergent set of relations with the communicating experts and the outcomes of the engagement project that were not able to be foreseen from the outset.

In my discussion chapter, I describe what I've learned about the awkwardness of wearing multiple hats at once in practice-based research, as both researcher and practitioner (in addition to being one's own research subject). I encourage the continuation of practice-based PhDs, but note several trade-offs that a practice-based mode of inquiry can introduce into the experience of doing a PhD and the quality of its products, as well as the quality of the media output. This mode of knowledge-making presents a destabilizing quality that practice-based researchers must come to terms with, which is particularly worth thinking about in the mixed community of practitioners and scholars that constitute the field of science communication. I also reflect on my own practice as a science engagement practitioner in light of criticisms in the field that say it may be too much to expect genuinely critical discourse to be possible when institutions that are interested in the promotion of synthetic biology are part of the structure that makes public engagement research and projects possible. I question the limits of the effect Aurator may be able to have given its embeddedness in a synthetic biology research network, relationship to funders that want to

see innovation in the field, as well as questions around what it means for synthetic biology to "perform its own responsibility" through engagement. Instead of being trapped by criticisms about the impacts of engagement, I agree with Morgan Meyer's suggestion to practitioners: we should develop flexible responses to these criticisms that include accepting them, rejecting them, and inverting their original meaning through honest acknowledgements of our communication goals and limits (2013).

I have demonstrated in this thesis that the participation of communicating experts in an engagement event is shaped by emotions and affective experiences that emerge throughout the event (their own emotions and affects as well as those of the engagement event's producer. I have also shown that the emotions and affective experiences of the event producer determine a variety of outcomes of the engagement event that are sometimes strong enough to overpower how communicating experts take up or resist their roles as participants, in terms of how they affect the overall communication that gets produced. My findings have therefore led me to make one principal argument about the function of emotion and affect in science communication, which is that science engagement practitioners should *care for science communication*. That is, they should operationalise an awareness about competing requirements for care and the need to asymmetrically balance them in an ultimately imperfect process when practicing emergent science communication (Horst and Michael 2011). Due to the performative nature of science communication, the asymmetries are always shifting in different times according to different pressures and priorities. Many scholars have argued for the necessity of care in science, and I have built on that foundation in this thesis, through my study of the function of emotion and affect in science communication, to demonstrate why we must also ensure that dynamic forms of care are built right into the fabric of how we design and carry out science engagement projects. This dissertation contributes to making this necessity explicit in our discussions about practice and ethics as science communicators.

As a result of this research, I have discovered that public engagement that is designed to be

open and emergent has an inescapably dynamic and unruly nature, and that what is needed to deal with the unforeseeable complexities of this is a practice of *caring for science communication* that explicitly acknowledges, prepares for, and responds to the fact that emotional and affective phenomena have significant direct impacts on our science communication activities. *Caring for science communication,* as I outline it here, includes cherishing the performative nature of science communication and the fact that knowledge gets made as science communication is happening; it is not always something one can prepare for. Being open to this performative character of science communication, which demands various types of emergent care along the way that could not be predicted at the start, is a way of caring in itself. My findings lead me to conclude that this kind of performativity, which is influenced by emotion and affect but also other material dimensions like time, duration, and external pressures from funders or collaborators, is at the core of what it means to do science communication. It is not that we do things as science communicators, come to regret them after we've learned from them, and later say we should have done them differently. Instead, we learn from what happens along the way, train our sensitivities from the experience, and move on in order to care for our science communication more fully with each step. In this way, the emotions and affects involved in science communication are "an ethico-political issue – one that is more complex than it might initially seem to be." (Puig de la Bellacassa 2011: 86). Our job now, as science communicators, is to *take better care* of *how we care* for all aspects of our work.

Appendix A

Consent form: Interdisciplinary communication in synthetic biology

Please indicate what your response is to each question below.

I consent to participating in the research project according to the description above. YES NO

If participating, please provide the address to which you would like the audio recorder to be sent in the mail:

I wish to remain anonymous in the recordings, such that my name, ranking and position are not shared publicly in the final media products of this research (audio walks, website).
YES NO

If you are willing to have your personal information shared publically, do you have specifications as to which information is shared? Ex, name only, professional position or rank only.
Describe:

I consent to allowing excerpts of my recordings be used in the weekly audio prompts that are sent to other participants throughout the recording period.
YES NO IT DEPENDS (if so, please describe)

I will upload my recordings to the privately shared folder:
Once a week Once a month

I consent to allowing the audio I record to be used in a potential project for public broadcast at a hypothetical date in the future:
YES NO

If so, do you wish to remain anonymous (no name, only job title) in the broadcast?
YES NO

Date:

Name:

Signature:

Appendix B

A descriptive account of Aurator's production

In order to make Aurator, I needed to partner with other talented individuals who had experience working in interactive media. This was my first foray into producing an i-doc, and I was on my own. However, a good friend of mine with a lot of interactive media production experience named Nadja Oertelt, was up for collaborating. Oertelt is a neuroscientist who went on to become a documentary filmmaker and interactive media producer. Over the last several years, Oertelt has been working at Harvard University producing interactive documentaries and educational modules about neuroscience for Harvard's online audiences for their Massive Open Online Course called MCB80X. She also recently participated in an interactive filmmaking program at CERN in Switzerland where programmers, storytellers, and scientists collaborate to make interactive media projects about CERN's Large Hadron Collider. Her expertise in the interactive space was invaluable to me, and she became Aurator's executive producer who could guide me in the production process. In order for Oertelt and I to plan the concrete details of the i-doc's production, we needed to map out the main purpose and intention of the project as we saw it, according to my project's theoretical framework. I provide that mapping of intentions below, however, it is important to note that the following is merely descriptive of what I wanted Aurator to do as an interactive documentary. It is not a description of what I wanted Aurator to do as a data-rich project that would allow me to analyse its processes and contents in order to answer my research questions, as I have already accounted for those considerations previously in the methodology chapter.

Who is invited to participate?

I envisioned the i-doc as being a place where general audiences are welcome - people spanning from my mother, to my dentist, to a synthetic biologist with a lifetime of experience, in order to

resist hegemony in the polyphony I was trying to establish. The key to thinking about audiences therefore began with ideas about accessibility.

The first target audience we envisioned - a core, engaged group - is synthetic biologists and associated practitioners involved in the field and related research areas from various disciplinary backgrounds (for example ethics, anthropology, art, design, etc.) Therefore, my communicating experts make up the core audience group. Through several conversations that I've had with members of this community at festivals and conferences, I know that they are interested in the possibilities that an i-doc made from audio diaries creates for exploring the ambiguities and complexities that may exist between synthetic biology and publics.

The second target audience we conceived is made of curious "do-it-yourself" scientists, students and members of the public who are engaged at the periphery of synthetic biology in the vast, enmeshed and interconnected communities of public lab and hacker spaces. This group is hungry to learn and engage, as evidenced by the growing interest in DIY and educational online learning spaces like edX, coursera, and the prolific YouTube science/learning space. Examples of relevant physical DIYbio sites include Genspace in Brooklyn, BioCurious in MountainView, and LaPaillasse in Paris.

The third target audience audience is the concerned and relatively non-expert public, interested in issues that clearly comprise both science and society such as climate change, GMO regulation, ageing, human body enhancement, cryopreservation, space colonization and public health. We hope to reach this community through partnerships with more traditional media sources, educational, and research networks through cross-promotion of the project.

When is the interactive participation happening?

The interactive participation that takes place on Aurator is happening on a browser-based

platform (website) on people's personal computers and on their mobile devices. Users may choose to only visit the website once, at any point, or they may come back multiple times and participate to differing degrees, according to their own desire.

What is the participant able to do?

The website becomes a platform for public engagement about synthetic biology that allows users to listen to excerpts from the expert audio diaries collected through this research, and with interactive hashtags, jump to the parts of the diaries they are most interested in (which are tagged by subject). By activating the user's microphone, they can speak back to the experts' diaries or start their own new audio diary as well as leave text comments, which may generate responses from other public visitors (or responding expert diarists) of its own.

What do I want the impact of my i-doc to be?

First and foremost, this i-doc creates a space for all users - regardless of background knowledge or disciplinary affiliation - to openly discuss how they feel about our synthetic biology, as well as interact with the diaries recorded by others. In this sense, the i-doc becomes a place that not only exhibits polyphonic discourse as it has already occurred (from the diary collection process with the communicating experts) but encourages new forms of polyphony in action (by encouraging publics to upload user-generated audio recordings). Due to the open-ended, durational, nature of the i-doc, I hope that the user-generated content it collects over the years will serve the wider community of practitioners, scholars, journalists and other interested parties as a resource for discovering new research topics and points of discussion from what people have contributed to the website. I also hope that the i-doc is a platform where individuals, regardless of their expertise, feel free to emote and share their feelings

including their pain and suffering as Michael and Brown suggest is a more "authentic" way to engage about science (2002). I would like the i-doc to be a space that normalizes the fact that feelings, emotions and affective elements are a part of science itself and the process of engaging with others about science.

What do I want the shift in thinking / understanding to be for the users?

The goal is for the user is to think about their own feelings, beliefs and cognitive responses to developments in synthetic biology today. Through responsive audio commenting and diary uploading, users have an opportunity to become part of an evolving lineage of human thought on that topic. If they choose not to contribute through commenting, they can simply continue to explore and listen to others' diaries.

I want users of this i-doc to feel moved (for example: affected, touched, surprised) by some of the audio diary content about synthetic biology that they hear. Where experts often conduct themselves by particular codified performances - performances of expertise - I want them to experience content that flips that performance on its head and allows for a wide variety of experts to communicate differently than might be otherwise expected. When a scientist talks about crying or kicking over trashcans after hearing reviewer's comments, and a social scientist exposes how they talk to their spouse about their work in private, and an artist categorically points fingers at other professions - I want those genuine moments, which are often difficult to access - to be heard by the users. In doing so, I want the users to understand that synthetic biology is not all that different from other domains of life even though it appears as a biotechnological power apart from the rest of the world and its social orders. Indeed, synthetic biology is like anything else, fueled by human feelings like hope and stress, and there are multiple points of affective entry into it. Most importantly though, I want users to start thinking about synthetic biology as a diverse collage of ideas and interests that are spoken for by more than just the hegemonic voice of the science

itself, but many other voices as well. By the nature of Aurator's polyphonic production methods, this i-doc should hopefully encourage that.

Navigating Aurator

Oertelt and I found a seamless way for users to navigate the linked thematic narratives in the audio diaries featured on Aurator through hashtags that relate to the subject being discussed in certain parts of each diary. Using hashtags, users are able to jump between discrete elements of the audio archive according to their own interests (for example: #governance, #biohacking, or #makingscience which would relate to parts of different diaries that speak about governance issues in synthetic biology, topics that are relevant to biohacker, or processes of doing scientific research respectively). Design elements are built into the platform to allow users to explore the audio diary archive at different scales, namely according to the individual who spoke them, or the hashtag category that they belong to. On screen, users can see the relationships that exist between different diaries and the users who they belong to, as well as the people who responded to their diaries.

Audio quality differs from diary to diary because the diarists all recorded their diaries themselves in different physical settings. Although they are all in English, there is a scrolling English text transcript that is linked to the audio as it is playing. For now, English is the primary language displayed in the scrolling text because all of the recordings were made by English speakers, and due to cost constraints that are associated with translation and transcribing.

Fundraising and production

Neither Oertelt nor I had any experience with coding nor design, and therefore we needed to bring on a team of professionals who could help us turn the concept of Aurator into a reality. To do this

would require not only money, but also the right connections to an interactive media production company that would be willing to work with us on this particular project. In the second year of my PhD, I received a Doctoral Scholarship from the Social Sciences and Humanities Research Council of Canada for the explicit task of building Aurator. This helped enormously but did not pay for all of its production costs. As a result, I also raised funds from the University of Warwick's Integrative Centre for Synthetic Biology in order to pay for the remainder of the production costs, which was an interesting process in its own right that taught me about how institutions view their public engagement goals, which I write about in my analysis. The funding, once we secured it all, allowed us to hire Helios Design Labs, an award winning multi-disciplinary interactive design studio located at the intersection of art and technology, which is based in my hometown of Toronto. We hired Mike Robbins as our lead technologist. Robbins is a partner at Helios Design Labs, where he has been working for the last 15 years. He oversees the interactive part of their creative output and his work has won a number of major awards and nominations, including a Peabody for Short History of Highrise, an Emmy, and has been featured in IDFA, Sheffield DocFest, smartFip@, Bristol iDocs and MIT Docubase. Robbins brought in a developer he likes to work with named Ewan Kass-Kavanagh to our production team. Kass-Kavanagh was principally responsible for building the "back end" of the platform, which allows Oertelt and I as moderators of Aurator to enter the part of the site that the public cannot see in order edit, delete or publish audio diary entries that the public adds to Aurator. Robbins on the other hand was principally responsible for building the "front end" of the platform - the part that users experience when they arrive to the www.aurator.org. From time to time, another developer named Dan Campell joined our meetings, as he was responsible for building the mobile version of Aurator. Alex Withholz helped our team as the designer who was responsible for creating the aesthetic backdrops that set the tone for the experience of using Aurator as well as wire-framing the overall layout, and lastly, Heather

Grieve helped with production coordination. Without this team, Aurator would not have been made. I a am so grateful for all of their hard work and dedication to the project.

In the spring of 2016, we began having regular weekly meetings over Skype to discuss the project overview, build strategy, role delegation, design, and necessary iterations on the i-doc concept. When we had things to discuss outside of our meeting times, we used the collaboration platform Slack to converse with each other. These weekly meetings lasted all through the spring, summer, and fall of 2016. In fact, they lasted far longer than they were supposed to, because our original production schedule indicated that Aurator would be completed by the end of September, but we were still regularly working together on the project until January 2017. As I've learned in other media productions, things often take a lot more time than you originally plan them to.

Working with Helios - a leading interactive design studio - was an experience full of revelations for me. Having never produced an interactive media project for web and mobile before, essentially all aspects of their production process were new to me and offered lessons at each stage of my exposure to them. Robbins explained that at Helios, they regularly test the i-doc concepts at the beginning of a project because the worst thing would be for one of their projects to develop a particular point in the design and coding, only for the creators to realize deep into the work process that they don't actually like the direction it is going in. Therefore, they work iteratively when collaborating with creators like me, testing each concept we discuss seriously in a rough prototype, which Robbins calls a "code sketch." A code sketch can be considered a minimal viable prototype that expresses an idea in code so that it plays out on the digital devices it is designed for. Just as a painter makes a sketch before applying paint, Robbins would make little code sketches and send them to our team on Slack so we could approve or disapprove. By the end of our production, I had seen approximately thirty code sketches from Robbins on different aspects of the platform's look and functionality.

Here is an example of how a code sketch affected the outcomes of Aurator: one day after we had been meeting as a team for about a month, Oertelt suggested that we should take some visual inspiration from fractal shapes for the aesthetic design of the platform. I agreed that there was something interesting about how fractals, as they loosely relate to some of the concepts that undergird synthetic biology such as mathematical and thereby computational logic applied to nature (since fractals result from math affecting organic shapes). These were just passing remarks we made about some designs directions we might use, but Robbins quickly applied them in a code sketch. He found some algorithms that draw digital fractals, and made a code sketch that allowed us to see how an audio diary, as it is being played on a web browser, could cause a fractal pattern to grow on the screen in relation to the voice of the speaker when listening to a diary (its volume and duration). This gave us a sense for what the fractal algorithm felt like as it helped the site perform the audio diary content. Though it wasn't perfect at first, there was something attractive about the way it allowed you to both look at something interesting on the screen and also focus on the audio being spoken instead of distracting you with complex visuals. We refined the idea through several conversations about that one code sketch, and consequently Robbins ended up implementing the fractal feature into the final version of the project. This would happen again and again with different features of the platform's function and design.

Designing audio playback and diary display

While thinking about how to arrange the diaries into relevant and salient clips that could play in manageably short durations on Aurator, I was looking around for examples of other audio-driven media that had to tackle similar needs. I came across an app called Anchor, produced by WNYC (New York Public Radio) that was intended to try and make audio clips sharable on social media to wide audiences (audio does not go viral the same way video does, and WNYC wanted to see if it could be done with

Anchor). What I discovered from Anchor's design is that it limits how long an audio recording can be, which they've pegged at two minutes. My first time using Anchor, I found a conversation as a string of several people's two minute recordings about political correctness and how it affects people's behavior. I kept a journal of my reflections as I listened to the recordings and wrote, "As I listen to two minutes or less per recording from each user, I am truly happy to keep listening to a few more people's responses. It doesn't feel like it is too long to listen to. But if they were longer than two minutes each I imagine I would not hang around a lot longer to hear more." This gave me an idea for how long I should allow Aurator's users to speak while responding to the core diaries, or uploading their own new audio diaries.

However, it was important that I remained clear on understanding the difference between Anchor and Aurator, and not just super-impose its lessons onto my own production. Anchor is first and foremost focused on trying to find ways that audio can be socially sharable (which does of course lead to engagement). But it puts social first, whereas I put listening and engagement first through direction platform interaction, and don't privilege the ability of media on Aurator to go viral on Facebook and Twitter platforms (though of course my engagement goals could be assisted if the audio on Aurator were highly sharable on social media). This was a key difference and meant that I did not have to jeopardize the meaning of the core diaries for their susceptibility to sharing. Often my diarists would record an hour or more of diary tape when responding to a prompt. Sometimes a single idea they were exploring would go on for more than twenty minutes. Therefore, in some cases, editing their diaries down to a two-minute chunk would do them a great disservice, because much of the meaning or illustration of their thoughts would have to be cut out. Since I was not focused on turning the core diaries into viral media, I decided it was a good idea to let the diaries for themselves when editing them down. I let the diaries take the amount of time they required in order to get a specific relevant or salient point about synthetic biology across in the audio file that would make its way onto Aurator for users to listen to. Often, I would take one diarist's full

response to a weekly prompt (that was an hour long, for example) and cut it down into five or so different diaries that would get separated according to the distinct thoughts contained within them, while also deleting a bunch of non-usable tape. Though I did try to keep the diary chunks relatively short, I would let them go on for up to five minutes if the meaning of the thoughts embedded in them required it. However, I learned from Anchor that I should put a time limit on how long users' recordings could be when they respond to the core diaries that were made by the communicative experts as well as when they create new diaries on the site, which I capped at two minutes each.

Each of the diary chunks that I cut my diarists' curated recordings into became a separately displayed diary entry on Aurator that users are able to listen to. I gave each small chunk a short title that described what a user could expect to hear if they clicked on that particular diary. I intended for the title to be intriguing, and so labeled them with titles that sometimes sounded puzzling or provocative. Often, I would just take a direct line from the transcript of something they'd said that piqued my interest or amused me as long as it also referred to what that diary entry was about. There were exactly 100 of these labeled diary entry chunks that were entered into Aurator's database. Examples of their names include: "Growing cells from dead rabbit eyes", "Genetic engineering as sex", "I kicked over a trashcan and freaked out", "I was heartbroken", "We can make dragons that breathe fire", "We're all gonna die, so what do you have?", "That was demoralizing and a bit depressing", "It would be great if it were all built on nonsense", "A small mammal that poos expensive coffee", " I am a very narrow minded scientist, groomed by the machine", and "It is going to change everything".

These newly labeled diary entries were first categorized according to the discipline of the person spoke them (ex: Scientist, Social Scientist, Watchdog, Bioethicist, Artist, Biohacker, Entrepreneur), and secondly also categorized according to what general topic the diary entry was about. As mentioned above, the general topics were denoted with a #hashtag that related to the overall topic I identified that

was most clearly discussed within each diary clip. The complete list of the hashtags that were attached to diary clips as metadata follows: #artdesign, #biohacking, #democracy, #applications, #artificiallife, #publicengagement, #makingscience, #hype, #tools, #inspirations, #unknowns, #emotions, #concerns, #limits, #genomeediting, #narratives, #histories, #futures, #philosophy, #speculative, #business, #metaphors. When assigning hashtags, I listened to each diary entry and tried to ascertain which general topic it most sensibly fit into. For example, I labeled diary entries with the #narratives tag that either a) contained an often repeated narrative in the field about how synthetic biology functions (even though there may be different popular narratives in the archive that contradict each other), and b) touch on possibilities for informing the narrative of synthetic biology in a specific way as discourse around the field continues to grow (such as an entrepreneur talking about how including artists in the field will allow us to frame the conversation around recreational drugs produced by synthetic biology differently than if scientists breach the topic with the public on their own. A diary entry like that would be labeled with the #narrative tag (as well as any others that fit, such as #artdesign).

The #hashtag system would allow for a user to click on the general topic when they saw a hashtag appear that they were interested in next to a playing diary entry. This way they could find more diaries they might like to hear about a specific topic, such as #futures or #business for example. Clicking on either hashtag would make all of the diary entries appear that any of the core diarists or public users (hereafter called "public voices") had recorded on those topics. This expanded the users' way of navigating the diary archive, which otherwise was only categorized and thus navigable according to the discipline of each diarist. When importing the diary content into Aurator's database, I entered all of the edited diary clips with three important pieces of metadata attached to them: title of diary, discipline of diarist, and corresponding #hashtag(s). A single diary could be assigned up to three different #hashtags, since diarists would often touch on multiple issues in a single thought scenario, and three was the recommended limit

that my collaborators who were coding the website suggested I use. With this database and associated metadata, Robbins was able to write code that clearly linked diary clips to disciplines and #hashtags that a user would be able to easily navigate using Aurator.

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